

U. S. DEPARTMENT OF AGRICULTURE,
OFFICE OF EXPERIMENT STATIONS,

A. C. TRUE, Director.

EXPERIMENTS

ON

LOSSES IN COOKING MEAT.

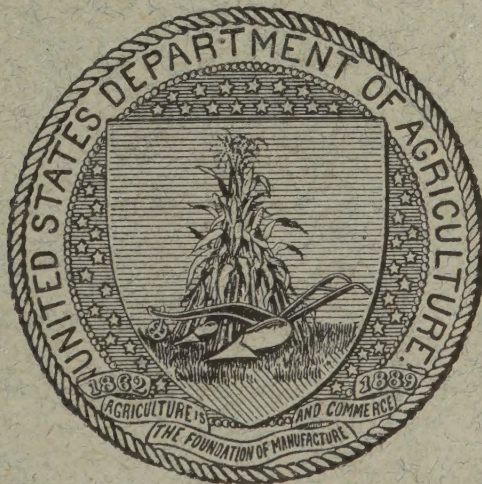
1898-1900.

By H. S. GRINDLEY, D. Sc.,

Associate Professor of Chemistry, College of Science, University of Illinois,

WITH THE COOPERATION OF

H. McCORMACK, M. S., and H. C. PORTER, M. S.



WASHINGTON:
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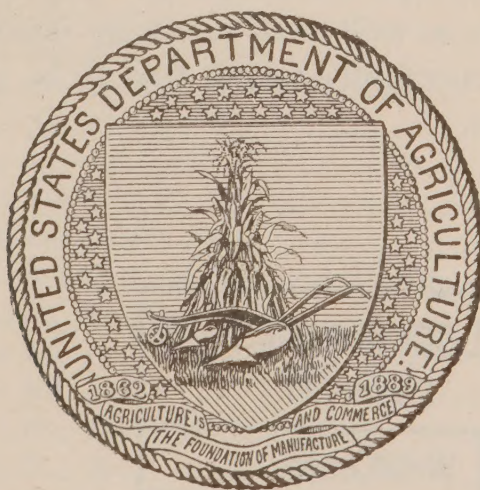
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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
OFFICE OF EXPERIMENT STATIONS,
Washington, D. C., July 26, 1901.

SIR: I have the honor to transmit herewith a report of investigations conducted in 1898 to 1900 by Prof. H. S. Grindley, associate professor of chemistry at the College of Science of the University of Illinois, with the cooperation of H. McCormack and H. C. Porter, the investigations being conducted under the general supervision of Prof. W. O. Atwater, special agent in charge of nutrition investigations, in accordance with instructions given by the Director of this Office. One of the objects of nutrition investigations is to learn the scientific principles which underlie the preparation of food and the changes which the application of heat in different ways brings about in food materials. This is the more necessary as up to the present time the majority of food investigations conducted in this country and Europe has had to do with other phases of the problem and little information has been available regarding changes brought about by cooking. In carrying out this work Professor Grindley has devoted his attention to meat of different kinds. Certain phases of the investigation are being continued and the data here given constitute a report of progress. The results already obtained are of practical value, as well as of scientific interest, and the report is submitted with the recommendation that it be published as Bulletin No. 102 of this Office.

Respectfully,

A. C. TRUE,
Director.

Hon. JAMES WILSON,
Secretary of Agriculture.

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LOSSES IN COOKING MEAT.

INTRODUCTION.

Meats of various kinds enter largely into the dietaries of most American families. In an average of 185 dietary studies made in different parts of the United States, largely in connection with the investigations on the food and nutrition of man which have been carried on in cooperation with the U. S. Department of Agriculture, it has been found that flesh of all kinds, including meat and poultry, fish, and shellfish, forms 20 per cent of the total food. With such exceptions as dried beef and oysters, meat is rarely eaten raw, but for the most part is either roasted, boiled, fried, or stewed.

Among the chief objects sought in the cooking of meats are the loosening and softening of the tissues. This facilitates digestion by allowing more thorough mastication and consequently greater exposure to the action of the digestive juice. At the same time the various methods of cooking meat have different effects upon its chemical composition. Our knowledge concerning the effects of the cooking of meats upon either composition or digestibility, however, is not commensurate with the importance of the subject. These questions have a wide practical application as well as a scientific interest. In connection with the nutrition investigations of this Department, the author began, in 1898, at the University of Illinois, some investigations on the losses involved in the cooking of meats and on the digestibility of meats cooked in different ways. This bulletin reports twenty-five experiments made during the years 1898 to 1900 on the losses in meat by different methods of cooking. Seventeen digestion experiments made with healthy men, with a mixed diet which was fairly uniform except that the meat was cooked in different ways, are not yet reported.

HISTORICAL REVIEW.

Apparently there has been comparatively little experimental study of the chemical, histological, and other changes which different foods undergo during the process of cooking. Various writers discuss the effects of the cooking of foods upon their composition and digestibility, but their statements are based more largely upon conjecture than upon experimental inquiry. A summary of what had been found upon record

on the subject at the time was given in a chapter on the "Preparation of food" in a previous publication of this Office.¹

Among recent investigations on the effects of cooking upon vegetable foods are studies of the losses of nutrients in the boiling of potatoes, carrots, and cabbage, reported by Snyder, Frisby and Bryant,² and studies of the losses involved in the process of breadmaking, reported by Voorhees,³ Bevier,⁴ Snyder,⁵ and Woods.⁶

Concerning the amount of loss resulting from the cooking of meats Thudichum⁷ gives the following figures: Twenty-eight pieces of beef, weighing 280 pounds, lost in boiling 73 pounds 14 ounces, or 26½ per cent; 19 pieces of beef, weighing 190 pounds, lost in roasting 61 pounds 2 ounces, or 32 per cent; 9 pieces of beef, weighing 90 pounds, lost in baking 27 pounds, or 32 per cent; 27 legs of mutton, weighing 270 pounds, lost in boiling 55 pounds 8 ounces, or 21½ per cent; 35 shoulders of mutton, weighing 350 pounds, lost in roasting 109 pounds 10 ounces, or 31½ per cent; 16 loins of mutton, weighing 141 pounds, lost in roasting 49 pounds 14 ounces, or 35½ per cent; 10 necks of mutton, weighing 100 pounds, lost in roasting 32 pounds 6 ounces, or 32½ per cent. The results indicate that whether meat be boiled or roasted it loses during cooking from one-fifth to one-third of its weight. These losses, Thudichum states, are due to the cooking out of water, fat, and some extractives and salts. Similar figures for loss in weight during cooking of meats are given in the report of dietary studies carried on in hospitals for the insane in New York State.⁸

Vogel⁹ found that meat placed in cold water and cooked by gradual warming lost much nitrogen and gave a highly nitrogenous broth, while meat placed directly in boiling water retained its nitrogen and juice, but yielded a poor broth.

Cooked meats have frequently been the subject of chemical analysis, although the number of analyses of cooked foods is still very small in comparison with that of raw materials. Allen¹⁰ gives the analyses of a number of different kinds of cooked meats made in his laboratory by A. R. Tankard. Katherine I. Williams¹¹ gives the analyses of a considerable number of samples of cooked fish of different kinds. Many cooked meats have also been analyzed in connection with the nutrition

¹ U. S. Dept. Agr., Office of Experiment Stations Bul. 21, pp. 81-97.

² U. S. Dept. Agr., Office of Experiment Stations Bul. 43.

³ U. S. Dept. Agr., Office of Experiment Stations Buls. 35 and 67.

⁴ U. S. Dept. Agr., Office of Experiment Stations Bul. 52.

⁵ U. S. Dept. Agr., Office of Experiment Stations Bul. 67.

⁶ U. S. Dept. Agr., Office of Experiment Stations Bul. 85.

⁷ The Spirit of Cookery. London, 1895, p. 68.

⁸ See report on investigations of dietaries for the insane by W. O. Atwater, in Eleventh Annual Report New York State Commission in Lunacy, Albany, N. Y., 1900.

⁹ Chem. Centbl., 55 (1884), p. 639.

¹⁰ Commercial Organic Analysis, vol 4. Philadelphia, 1898, p. 275.

¹¹ Jour. Chem. Soc. London, 71 (1897), p. 649.

investigations carried on in cooperation with this Department. In none of these cases, however, was the composition of the same meats determined before cooking. There is, therefore, no means of computing from these analyses the losses resulting from the cooking.

Church¹ says: "To show the influence of cooking upon a mutton chop, we may cite two analyses, in one of which (a) the gravy and drippings were carefully preserved and analyzed with the lean cooked meat of the chop, while in the other case (b) they were excluded."

Composition of cooked mutton chop.

Sample.	Water.	Protein.	Fat.	Ash.	Undetermined.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Chop with gravy and drippings.....	54	27.6	15.4	3.0	.....
Chop without gravy and drippings.....	51.6	36.6	9.4	1.2	1.2

In regard to these figures, however, Allen² states that "the two analyses are evidently quite different and do not represent the composition of the same chop with and without the gravy and drippings."

König³ reports three experiments made in his laboratory on the losses in cooking meats, two by roasting and one by boiling. The figures which he gives for the fresh, i. e., undried, substances are shown in the following table. The composition of each material has been calculated to water-free substance also, that the difference between the cooked and the uncooked meat may be brought out more clearly:

TABLE 1.—*Composition of meats before and after cooking.*

Sample.	In fresh substance.					In water-free substance.				
	Water.	Nitrogenous matter.	Fat.	Extractive matter.	Salts.	Nitrogen.	Nitrogenous matter.	Fat.	Extractive matter.	Salts.
Beef:	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>
Raw	70.88	22.51	4.52	0.86	1.23	12.37	77.31	15.47	2.98	4.24
After boiling.....	56.82	34.13	7.50	.40	1.25	12.65	79.06	17.38	.90	2.66
After broiling....	55.39	34.23	8.21	.72	1.45	12.27	76.73	18.41	1.59	3.27
Veal cutlets:										
Raw	71.55	20.24	6.38	.68	1.15	11.39	71.17	22.45	2.32	4.06
After roasting....	57.59	29.00	11.95	.03	1.43	10.93	68.36	28.18	.09	3.27

The figures in this table do not give a fully satisfactory measure of losses involved in the cooking of meats. In each case there is a larger proportion of fat in the cooked meat than in the raw sample. From the amount of the increase it would appear that fat had been added to the meat in the cooking. The proportion of nitrogen in one instance is also somewhat higher in the cooked than in the uncooked meat. This may be due to the decrease in the amount of salts and extractive matter

¹ Food. New York, 1877, p. 152.

² Commercial Organic Analysis, vol. 4. Philadelphia, 1898, p. 275.

³ Chemie der menschlichen Nahrungs-und Genussmittel. Berlin, 1893. Ed. 3, vol. 2, p. 1247.

in this sample. The differences in the composition of the uncooked and the cooked meats in the above experiments, however, may be due to actual differences in composition of the samples taken. It has been found in the investigations reported in this bulletin that perhaps the greatest difficulty in determining the losses in meat during cooking by comparing the analysis of a raw sample with that of a cooked sample is in obtaining two samples of raw meat that are sufficiently alike in composition.

With the special object of determining the comparative value of light and dark meat in the diet of invalids, Offer and Rosenquist¹ studied the character of the nitrogenous constituents of fish, poultry, and different kinds of raw and preserved meat, as well as of raw and fried veal. The study involved determination of total nitrogen, nitrogen of extractives, and nitrogen of meat bases. Constant differences between light and dark meat were not found.

So far as the author has been able to find, there are recorded no investigations made in the United States on the nature and extent of the various changes which occur in the cooking of meats and the losses involved in the different processes of cooking. The author's investigations were undertaken for the purpose of determining the amount and nature of such losses, and also the effects of different methods of cooking upon the digestibility of the meat.

ANALYTICAL AND EXPERIMENTAL METHODS.

The methods of analysis adopted in these investigations were mainly those recommended by the Association of Official Agricultural Chemists,² with such minor modifications as were found expedient. In the first experiments the meat used was beef round, as lean as could be secured. In the later experiments other cuts of beef were used, in addition to a few cuts of pork, veal, and mutton. In some of the experiments all visible fat was removed from the sample; in others the entire sample, including the fat, was used. In the experiments on the "pan-broiling" of meat the sample for each experiment was ground in a sausage mill, and the minced meat was then intimately mixed. This operation of grinding and mixing was performed three times, after which two samples of the meat were taken, one for analysis and one for cooking. In the earlier experiments on the boiling of meat the portion selected for each experiment was cut into pieces weighing from 2 to 4 pounds each; one piece was selected for analysis, and another which, judging from appearances, was just like it was used for cooking. The method, however, proved unsatisfactory, because it was found impossible to obtain two pieces that were even approxi-

¹ Berlin. Klin. Wehnschr., 36 (1899), pp. 937, 968, and 1086.

² U. S. Dept. Agr., Division of Chemistry Bul. No. 46, revised.

mately alike, although the greatest care was observed in selecting and dividing the cut of meat. It was therefore found necessary in the later experiments on the effects of boiling meat to make complete analyses of both the cooked meat and the broth or soup resulting, and in addition to determine the loss, if any, due to a volatilization of nutrients.

PREPARATION OF AIR-DRY SAMPLE.

In preparing the air-dry samples of raw meat, a portion was passed three times through a sausage mill, the ground meat being intimately mixed after each grinding. The sample was then weighed in a porcelain dish and placed in a water-jacketed oven, which was kept at a temperature of 90° to 95° C. The drying continued for twenty-four to thirty-six hours. The sample was then removed from the oven, loosely covered, and allowed to stand in the laboratory for about twenty-four hours, after which it was weighed. Air-dry samples of cooked meats were prepared in a similar manner.

DETERMINATION OF LOSS OF NITROGEN IN DRYING SAMPLES OF MEAT.

The loss of nitrogen resulting from the preparation of the air-dry samples of the meats was determined in several instances. The meat was dried in an oven which could be tightly closed, with the exception of an entrance and an exit for a current of air. Before entering the oven the current of air was passed through a Drechsel wash bottle (No. 1), containing sulphuric acid, to remove water vapor and organic matter. The air that left the oven was passed through two similar bottles (Nos. 2 and 3), also containing sulphuric acid, in which it was fair to assume any volatile nitrogenous compounds set free from the meat would be caught. By means of a suction pump a current of air was drawn through the oven as rapidly as possible without causing the acid in the bottles to spatter. After the meat was dried the amount of nitrogenous material removed was learned by determining (by the Kjeldahl method) the nitrogen in bottles No. 2 and No. 3. Table 2 gives the results of six such tests:

TABLE 2.—*Loss of nitrogen in drying meat (lean beef) in air.*

Laboratory No.	Length of time in oven.	Temperature of oven.	Weight of fresh meat.	Proportion of nitrogen in fresh meat.	Amount of nitrogen in fresh meat.	Amount of nitrogen found in acid.	Proportion of total nitrogen in fresh meat lost in drying.
	Hours.	°C.	Grams.	Per cent.	Grams.	Gram.	Per cent.
411.....	8	102	48.40	2.96	1.43	0.0015	0.11
418.....	8	102	52.94	3.13	1.66	.0015	.09
419.....	60	98	736.12	3.10	22.82	.0749	.33
431.....	60-70	50	724.45	3.60	26.08	.3845	1.47
450.....	56	98	761.83	3.54	27.00	.2310	.86
451 a.....	36	102	776.69	3.55	27.57	.0716	.26

a Dried in current of hydrogen instead of air.

In case of two samples (Nos. 411 and 418) the method of drying was modified somewhat. The total sample of meat in each test was divided into portions of about 5 grams each, and these were placed in the oven in shallow, flat-bottomed dishes, which had been heated to 102°C ., and the drying continued for eight hours. The proteid of the meat was quickly coagulated at this temperature, and thus it seemed probable that the loss of volatile compounds may have been reduced to a minimum. The results of these two tests, showing respectively a loss of 0.11 and 0.09 per cent nitrogen after eight hours drying, are quite concordant, and indicate that the loss of nitrogen in drying samples of meat in this manner is inconsiderable.

In the case of sample No. 419 portions of the meat (in casseroles) weighing about 150 grams each were left in the oven (without stirring) for about sixty hours at a temperature of about 98°C . The water content of the meat was then found to be about 1.5 per cent. The loss of nitrogen during drying was 0.3 per cent. In the case of sample No. 431 the ground fresh meat was placed in the oven at 50°C . The drying was continued some two and one-half days. A temperature of 50° was maintained during the daytime, but the oven was allowed to cool every night. The cool samples were stirred each morning, thus exposing a fresh surface. The drying was continued in this way until the water content of the meat was found to be about 1.5 per cent; the oven was then allowed to cool, the meat was removed, passed through a sausage mill until finely divided, and returned to the oven for further drying. The samples dried by this method showed a maximum loss of nitrogen. This large loss was probably due to the long-continued drying, to the exposure of fresh surface by frequent stirring, and also to the low temperature, which was not sufficient to coagulate the proteids. It is believed that there was no loss of material in grinding the dried sample in the sausage mill, as the apparatus was readily taken apart, and extreme care was taken to remove with a camel's hair brush any particles adhering to the different parts.

In the case of samples Nos. 450 and 451 the loss in drying in a current of air is compared with the loss in drying in a current of hydrogen. The other conditions were the same except that the temperature of the oven was 4 to 5 degrees higher than during the drying in air, and the drying was therefore completed in a shorter time. The water content of the samples was practically the same in each test. The loss of nitrogen was small in both cases, but was greatest in the sample dried in air.

From these tests it appears that in preparing air-dry samples of meat it is possible to reduce the loss of nitrogen to less than 1 per cent of the total amount present. Such a quantity is quite within the limit of error usually assumed in the analyses of foods and feeding stuffs.

The test with sample No. 419 was carried out in such a way as to bring out the effect of long-continued heating at a low temperature (50° C.) after the water content had been considerably reduced. The sulphuric-acid bottles were changed every twelve hours and the nitrogen was determined for each period. The results for the different periods are given in the following table:

TABLE 3.—*Loss of nitrogen from lean beef during successive twelve-hour periods, drying in air.*¹

Periods.	Nitrogen lost.	Proportion of total nitrogen lost.
	<i>Gram.</i>	<i>Per cent.</i>
First 12 hours	0.0111	14.8
Second 12 hours	.0033	4.4
Third 12 hours	.0029	3.9
Fourth 12 hours	.0160	21.4
Fifth 12 hours	.0416	55.5
Total, 60 hours	.0749	100.0

¹ See also sample No. 419, Table 2.

From these results it appears that the more volatile nitrogenous compounds were lost early in the drying, then the rate of loss decreased and was practically constant until the substance was nearly dry, and after that it increased very rapidly. This would indicate that the process of drying should not continue longer than is absolutely necessary to bring the sample into such a condition that it may be finely ground and thoroughly mixed.

DETERMINATION OF WATER.

A series of tests was made for the purpose of determining the loss in weight of samples dried at different temperatures and for different lengths of time. The samples were weighed in glass tubes with filter-paper bottoms, such as ordinarily used in ether extraction of fat by the Johnson method.¹ These were placed in a horizontal position in the drying oven and heated in a current of hydrogen. Table 4 gives the results of tests with eight samples taken from the same lot of meat, which had been ground in a sausage mill and intimately mixed, as previously explained. Four of the samples were dried at 98° C. and four at 102° C. In each case the loss in weight was determined when the sample had dried six hours. The sample was then returned to the oven and dried two hours longer and the loss in weight again determined.

¹Am. Jour. Sci., 13 (1877), p. 190.

TABLE 4.—*Percentage loss in weight of meat (lean beef) after drying different lengths of time and at different temperatures.*

Sample No.	Temperature of oven (° C.).	Loss after drying—	
		6 hours.	8 hours.
		<i>Per cent.</i>	<i>Per cent.</i>
1.....	98.....	30.40	30.45
2.....	98.....	30.92	30.90
3.....	98.....	30.70	30.74
4.....	98.....	30.88	30.96
Average, 4 samples		30.72	30.76
5.....	102.....	30.63	30.84
6.....	102.....	30.83	30.89
7.....	102.....	30.60	30.90
8.....	102.....	30.71	30.94
Average, 4 samples		30.69	30.89

From the figures in the table it appears that the loss in drying at 98° C. for eight hours differs but little from that at 102° for the same time, the average of four samples dried at 98° being 30.76 per cent, and that of four dried at 102° being 30.89 per cent, or a difference of only 0.42 per cent of the total weight of dried material. The loss at the end of six hours was found to be in some cases as great as at the end of eight hours. However, as the results at the end of eight hours seem more concordant, the drying was continued for that length of time in the investigations that follow.

DETERMINATION OF NITROGEN.

The determinations of nitrogen were made by the Kjeldahl process, with the adoption of precautions suggested by Hopkins.¹ Care was taken to test the accuracy of the manipulation and results. It has been found that there is great danger of incomplete ammonification of the nitrogen in animal tissues when treated with sulphuric acid and other reagents as ordinarily recommended in the Kjeldahl process. In order to test the effect of the duration of digestion upon the quantity of nitrogen found, three samples of meat were each divided into six subsamples, which were digested for different periods. In each case the first of the six was removed from the digestion furnace as soon as the liquid was clear, which was after about two and one-half hours' digesting, and the remainder of the six were removed at half-hour intervals. The results of these tests are given in Table 5.

TABLE 5.—*Effect of duration of digestion of lean beef with sulphuric acid upon the quantity of nitrogen found.*

Laboratory No.	Sample.	Nitrogen obtained after digesting—					
		2½ hours.	3 hours.	3½ hours.	4 hours.	4½ hours.	5 hours.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
439	Beef.....	12.05	12.07	12.16	12.19	12.27	12.26
440	do.....	12.72	12.75	12.76	12.78	12.80	12.79
444	do.....	12.54	12.71	12.76	12.76	12.84	12.81

¹ Illinois Station Bul. 53.

The results in Table 5 indicate that the samples were not completely digested at the time the sulphuric-acid solution had become colorless, but, as has been pointed out by Atwater and Woods¹ and by Goss,² it is necessary to continue the digestion for some time after the solution becomes decolorized. The maximum amount of nitrogen was found after the digestion had been continued four and one-half hours, or two hours after the solution had become colorless. For the sake of accuracy in the following investigations, therefore, the digestion was continued four and one-half to five hours.

In the experiments after No. 6 both proteid³ and nonproteid nitrogen were determined in making the analyses of the broths.⁴ The proteid nitrogen was determined by the bromin method.⁵ The broth was acidulated with hydrochloric acid and bromin was added in excess, and the mixture well shaken and allowed to stand for a considerable time, usually overnight. The nitrogen was determined in the precipitated albuminoids by the usual method. This was considered as proteid nitrogen, and the amount multiplied by the factor 6.25 was taken as the amount of proteids in the broth. The difference between the proteid nitrogen and the total amount of nitrogen in the broth was taken as nonproteid nitrogen. This latter amount was multiplied by the factor 3.12 and the product was considered as representing the amount of flesh bases present in the broth.

¹U. S. Dept. Agr., Office of Experiment Stations Bul. 44, p. 25.

²U. S. Dept. Agr., Office of Experiment Stations Bul. 54, p. 12.

³Unfortunately the terms given by different writers to nitrogenous compounds in foods are very conflicting. In accordance with common usage the term protein is here made to cover all the nitrogenous compounds except the nitrogenous fat, although the word proteid is sometimes used with this significance. The protein compounds may be roughly divided into three groups. The first will include the most important of the nitrogenous nutrients, such as albumin, myosin, etc., which are sometimes grouped together as albuminoids. With these may be grouped the so-called gelatinoids, such as chondrigen, gelatin, etc., derived from animal connective tissue. This second class is by some writers called proteids and by others albuminoids; both of these classes are here grouped as proteids. Distinguished from these are the third group, the nonproteids, including the creatin, creatinin, and other nitrogenous extractives of meat. The compounds of this group are here designated as flesh bases. It is assumed that the proteids contain 16 per cent of nitrogen, and their amount is therefore calculated by multiplying the quantity of nitrogen by 6.25. It is likewise assumed that the flesh bases contain 32 per cent of nitrogen and their amount is computed by multiplying the nonproteid nitrogen by 3.12. Both of these factors are based more or less upon assumption. Where the proteid and nonproteid compounds are not distinguished in the following experiments the protein has been computed by multiplying the total nitrogen by 6.25. There is, of course, still more uncertainty as to whether this factor gives approximately correct results. For further discussion of this subject see U. S. Dept. Agr., Office of Experiment Stations, Bul. 65, p. 118; and Allen's Commercial Organic Analysis, vol. 4. Philadelphia, 1898, p. 308.

⁴For a description of the broth and methods of analysis, see p. 21.

⁵See U. S. Dept. Agr., Division of Chemistry Bul. 54.

DETERMINATION OF FAT.

The determination of fat was made by extraction with anhydrous ether for twenty-four hours, in a Soxhlet apparatus fitted with a Hopkins reflux condenser. The samples used for the determinations of fat were those in which water had been removed by the method previously described. These samples were contained in glass tubes fitted with filter-paper bottoms. These tubes were placed in larger tubes similarly fitted; thus the fat was filtered twice, and the danger of any solid matter passing through was reduced to a minimum.

In order to test the completeness of the removal of fat from the samples by extraction for twenty-four hours, clean flasks were attached to four tubes after the extraction had been carried on that length of time and the process was continued eight hours longer. The material contained in the flasks at the end of the eight hours amounted, respectively, to 0.031, 0.038, 0.074 and 0.032 per cent of the original samples. These results indicate that the removal of the fat was practically complete after extraction for twenty-four hours.¹

COMPOSITION OF MEAT AS ANALYZED WITHOUT PRELIMINARY DRYING.

Before the investigations upon the losses occurring in the preparation of an air-dry sample of meat had been made, as reported above, it was thought that the losses in drying the samples would be as great as, if not greater than, those involved in some methods of cooking meats. An effort was therefore made to adapt the ordinary methods to the analysis of fresh meat without preliminary drying. The samples were first prepared as usual by removing the visible fat mechanically and by grinding the meat as fine as possible in a sausage mill and then thoroughly mixing it. A portion of the freshly ground material was analyzed without preliminary drying and a similar portion was analyzed in the usual way after partial drying. The determination of nitrogen in the fresh sample was made by the Kjeldahl method, as in the air-dry sample. The determination of water was made on samples of about 5 grams, which were placed in shallow porcelain dishes and dried in a hydrogen oven for eight hours. After these samples were weighed they were transferred to fat-free capsules and extracted with ether for twenty-four hours for the determination of fat. The results of the analyses of a number of samples of both cooked and uncooked meat made in this way without preliminary drying are given in the following table, in comparison with analyses

¹For discussion of the complete extraction of fat see the following: Die quantitative Bestimmung von Fett in thierischen Organen; C. Dormeyer, Pflüger's Arch. Physiol., 61 (1895), pp. 341-343; and Ein Beitrag zur Methode der Fettbestimmung; E. Voit, Ztschr. Biol., 35 (1897), No. 4, pp. 555-582.

of other portions of the same samples made in the usual way with partial drying:

TABLE 6.—*Composition of meat (lean beef) as determined with and without drying before analysis.*

Laboratory No.	Condition of sample.	In fresh substance.					In water-free substance.			
		Water.	Protein.	Fat.	Ash.	Total.	Protein.	Fat.	Ash.	Total.
		<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>
395	Uncooked, not dried.....	74.29	21.25	2.41	1.10	99.05	82.65	9.37	4.28	96.30
395	Uncooked, partially dried..	75.17	21.20	2.49	1.17	100.03	85.39	10.03	4.69	100.11
396	Uncooked, not dried.....	74.22	21.08	3.39	1.10	99.79	81.77	13.15	4.26	99.19
396	Uncooked, partially dried..	74.77	21.44	2.48	1.15	99.84	84.98	9.81	4.56	99.35
398	Cooked, not dried.....	62.48	32.26	3.24	1.34	99.32	85.98	8.64	3.57	98.19
398	Cooked, partially dried....	61.68	33.38	3.93	1.58	100.57	87.08	10.26	4.12	101.46
399	Cooked, not dried.....	64.57	30.39	3.35	1.44	99.75	85.77	9.42	4.06	99.33
399	Cooked, partially dried....	64.77	30.37	3.44	1.49	100.07	86.20	9.76	4.22	101.18
405	Uncooked, not dried.....	73.07	21.05	3.75	1.13	99.00	78.16	13.92	4.19	96.27
405	Uncooked, partially dried..	72.81	21.75	3.53	1.12	99.21	80.00	12.96	4.12	97.08
413	Uncooked, not dried.....	74.21	21.80	2.13	1.20	99.34	84.53	8.26	4.65	97.44
413	Uncooked, partially dried..	74.76	21.70	2.18	1.16	99.80	85.98	8.62	4.58	99.18
414	Uncooked, not dried.....	74.19	21.53	2.24	1.25	99.60	83.41	8.68	4.84	96.93
414	Uncooked, partially dried..	74.73	21.67	2.15	1.13	99.68	85.71	8.52	4.49	98.72
416	Cooked, not dried.....	62.25	32.23	3.59	1.53	99.60	85.37	9.51	4.05	98.93
416	Cooked, partially dried....	62.24	32.34	3.60	1.56	99.74	85.65	9.54	4.13	99.32
417	Cooked, not dried.....	63.47	31.19	3.21	1.67	99.54	85.38	8.79	4.57	98.74
417	Cooked, partially dried....	63.67	31.20	3.06	1.64	99.57	85.88	8.42	4.51	98.82

Some of the analyses made without preliminary drying given in the table above were not satisfactory—for instance, Nos. 395, 405, and 414—but as the samples of fresh meats had decomposed before they were completed it was not possible to repeat them. This danger of decomposition is a serious objection to the practice of making analyses of fresh meats without partial drying. It will be observed that, with few exceptions, the results of the analyses made directly upon the fresh substance do not apparently differ materially from those made on a portion of the same material partially dried, when calculated to the fresh substance; but when the results are calculated to a water-free basis there are in some cases wide differences in the proportions of constituents in the same sample. This is probably due in part to the difficulty of preventing a loss of water while weighing samples of fresh meat. Furthermore, it is almost impossible to determine the water content of fresh meat by the method used, as the samples become coagulated upon the surface soon after being placed in the oven, and traces of moisture are left in them even after prolonged heating.

In analyses of carcasses of pigs Wiley¹ determined the water by two methods. The cut of meat to be analyzed was passed through a meat chopper two or more times. For the direct determination of water 5 grams of this chopped meat was dried in vacuo at 105° C. for six hours and the loss in weight taken as water. From 400 to 600 grams of the same large sample of chopped meat was dried in air in a steam oven at a temperature of about 100°, the loss in weight representing the

¹ U. S. Dept. Agr., Division of Chemistry Bul. 53, p. 9.

water removed. The water in the air-dried or partially dried sample was determined by drying 2 grams of the material in vacuo at 100° for six hours. In nearly every case a lower figure was obtained by the direct determination of water than by taking the sum of the water removed in air drying and that found in the air-dried material.

LOSSES OF MATERIAL IN THE COOKING OF MEATS.

In the investigation on the losses involved in the cooking of meats different methods of cooking were adopted. In four of the experiments the meat was cooked by "pan-broiling;" in the others it was cooked in water at different temperatures, the exact method followed in each case being given in the descriptions of the individual experiments. The experiments on the losses by "pan-broiling" were undertaken first, because it was thought that conditions necessary for accurate results could be obtained more easily by this method than by boiling, and it was believed that the experience gained in these experiments and the results obtained would be of value in carrying out the more complicated experiments on boiling.

EXPERIMENTS MADE DURING 1898-99.

LOSSES IN MEATS COOKED BY "PAN-BROILING."

EXPERIMENTS NOS. 1, 2, 3, AND 12.

In the following experiments (Nos. 1, 2, 3, and 12) an attempt was made to determine the losses occurring in the "pan-broiling" of meats by comparing the composition of the raw meat with that of the meat after cooking. For this purpose it was necessary to secure two samples that were alike in composition before cooking. Beef round was used, as lean as could be secured, and from this all bone, gristle, and visible fat were removed. The lean meat was then passed three times through a sausage mill, and the ground meat was intimately mixed each time. The finely divided meat was then made into cakes weighing 60-80 grams each, which were approximately the same in composition. Part of these were analyzed raw and part after cooking.

The method by which the meat was cooked in these experiments has been called "pan-broiled;" that is, it was cooked in a medium hot frying pan without addition of fat.

After the meat was cooked for a certain length of time, which is stated in the details of each experiment, it was removed from the frying pan, care being taken to scrape off as much as possible of the material adhering to the pan, and was cooled and weighed.

The following tables, 7 to 14, contain the data of these experiments. The first table in each experiment gives the composition of both the fresh material and the water-free substance of the uncooked and cooked meat. It will be observed that in most cases the sum of the percentages of the constituents is a trifle less than 100, although in three instances it is a little over 100. These discrepancies are due to unavoidable errors in the analyses or in methods followed.

The second table in each experiment gives the total weight of the uncooked and cooked meat, the weights of the constituents in each as calculated from the total weight and the composition given in the first table, and the differences between the weights of constituents in the uncooked meats and those in the cooked meats.

TABLE 7.—*Composition of uncooked and cooked lean beef (cooking experiment No. 1).*

Laboratory No.	Sample.	Composition of fresh material.					Composition of water-free substance.			
		Water.	Protein.	Fat.	Ash.	Total.	Protein.	Fat.	Ash.	Total.
		<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>
395	Uncooked beef.....	75.17	21.20	2.49	1.17	100.03	85.39	10.03	4.69	100.11
398	Cooked beef.....	61.68	33.38	3.93	1.58	100.57	87.08	10.26	4.12	101.46
396	Uncooked beef.....	74.77	21.44	2.48	1.15	99.84	84.98	9.81	4.56	99.35
399	Cooked beef.....	64.77	30.37	3.44	1.49	100.07	86.20	9.76	4.22	100.18

TABLE 8.—*Total weight of uncooked and of cooked lean beef, and weights of different constituents in each, with loss during cooking (experiment No. 1.)*

Laboratory No.	Sample.	Total weight of material.	Weight of constituents.			
			Water.	Protein.	Fat.	Ash.
	FIRST TEST.					
		<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>
395	Fresh meat taken.....	289.5	217.6	61.4	7.2	3.4
398	Same broiled 20 minutes.....	187.8	115.8	62.7	7.4	3.0
	Loss (—) or (apparent) gain (+)	—101.7	—101.8	+ 1.3	+ .2	— .4
	SECOND TEST.					
396	Fresh meat taken.....	259.8	194.3	55.7	6.4	3.0
399	Same broiled 15 minutes.....	185.7	120.3	56.4	6.4	2.8
	Loss (—) or (apparent) gain (+)	— 74.1	— 74.0	+ .7	.0	— .2

TABLE 9.—*Composition of uncooked and cooked lean beef (cooking experiment No. 2).*

Laboratory No.	Sample.	Composition of fresh material.					Composition of water-free substance.			
		Water.	Protein.	Fat.	Ash.	Total.	Protein.	Fat.	Ash.	Total.
		<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>
405	Uncooked beef.....	72.81	21.75	3.53	1.12	99.21	80.00	12.96	4.12	97.08
408	Cooked beef.....	62.80	30.06	4.70	1.49	99.05	80.81	12.63	4.00	97.44
407	Uncooked beef.....	73.79	20.95	3.47	1.09	99.30	79.91	13.23	4.16	97.30
409	Cooked beef.....	64.12	28.52	4.68	1.30	98.62	81.33	13.04	3.61	97.98

TABLE 10.—*Total weight of uncooked and cooked lean beef, and weights of different constituents of each, with loss during cooking (experiment No 2).*

Laboratory No.	Sample.	Total weight of material.	Weights of constituents.			
			Water.	Protein.	Fat.	Ash.
	FIRST TEST.					
405	Fresh meat taken.....	Grams. 237.3	Grams. 172.8	Grams. 51.6	Grams. 8.4	Grams. 2.6
408	Same broiled 17 minutes.....	182.4	114.6	54.8	8.6	2.7
	Loss (—) or (apparent) gain (+)	— 54.9	— 58.2	+ 3.2	+ .2	+ .1
	SECOND TEST.					
407	Fresh meat taken.....	245.1	180.9	51.3	8.5	2.7
409	Same broiled 17 minutes.....	186.0	119.3	53.0	8.7	2.4
	Loss (—) or (apparent) gain (+)	— 59.1	— 61.6	+ 1.7	+ .2	— .3

TABLE 11.—*Composition of uncooked and cooked lean beef (cooking experiment No. 3).*

Laboratory No.	Sample.	Composition of fresh material.					Composition of water-free substance.			
		Water.	Protein.	Fat.	Ash.	Total.	Protein.	Fat.	Ash.	Total.
413	Uncooked beef.....	<i>P. ct.</i> 74.76	<i>P. ct.</i> 21.70	<i>P. ct.</i> 2.18	<i>P. ct.</i> 1.16	<i>P. ct.</i> 99.80	<i>P. ct.</i> 85.98	<i>P. ct.</i> 8.62	<i>P. ct.</i> 4.58	<i>P. ct.</i> 99.18
416	Cooked beef	62.24	32.34	3.60	1.56	99.74	85.65	9.54	4.13	99.32
414	Uncooked beef.....	74.73	21.67	2.15	1.13	99.68	85.71	8.52	4.49	98.72
417	Cooked beef	63.67	31.20	3.06	1.64	99.57	85.88	8.42	4.51	98.82

TABLE 12.—*Total weight of uncooked and cooked lean beef, and weights of different constituents in each, with loss during cooking (experiment No. 3).*

Laboratory No.	Sample.	Total weight of material.	Weights of constituents.			
			Water.	Protein.	Fat.	Ash.
	FIRST TEST.					
413	Fresh meat taken.....	Grams. 210.3	Grams. 157.2	Grams. 45.6	Grams. 4.6	Grams. 2.4
416	Same broiled 17 minutes.....	139.9	87.1	45.2	5.0	2.2
	Loss (—) or (apparent) gain (+)	—70.4	—70.1	— .4	+ .4	— .2
	SECOND TEST.					
414	Fresh meat taken.....	210.9	157.6	45.7	4.5	2.4
417	Same broiled 17 minutes.....	146.6	93.4	45.8	4.5	2.4
	Loss (—) or (apparent) gain (+)	—64.3	—64.2	+ .1	.0	.0

TABLE 13.—*Composition of uncooked and cooked lean beef (cooking experiment No. 12).*

Laboratory No.	Sample.	Composition of fresh material.					Composition of water-free substance.			
		Water.	Protein.	Fat.	Ash.	Total.	Protein.	Fat.	Ash.	Total.
495	Uncooked beef.....	<i>P. ct.</i> 75.05	<i>P. ct.</i> 22.02	<i>P. ct.</i> 1.70	<i>P. ct.</i> 1.09	<i>P. ct.</i> 99.88	<i>P. ct.</i> 88.34	<i>P. ct.</i> 6.83	<i>P. ct.</i> 4.39	<i>P. ct.</i> 99.56
493	Cooked beef	65.35	30.51	2.57	1.49	99.92	88.05	7.42	4.29	99.76
497	do.....	65.62	30.31	2.59	1.47	99.99	88.17	7.54	4.29	100.00
	Average 493 and 497	65.49	30.41	2.58	1.48	99.96	88.11	7.48	4.29	99.88
496	Uncooked beef.....	75.19	21.89	1.76	1.12	99.96	88.15	7.08	4.52	99.75
494	Cooked beef	64.12	31.57	2.59	1.50	99.78	87.99	7.21	4.17	99.37
498	do.....	64.15	31.54	2.56	1.53	99.78	87.97	7.14	4.28	99.39
	Average 494 and 498	64.14	31.56	2.58	1.52	99.78	87.98	7.18	4.23	99.38

TABLE 14.—*Total weight of uncooked and cooked lean beef, and weight of different constituents in each, with loss during cooking (experiment No. 12).*

Laboratory No.	Sample.	Total weight of material.	Weights of constituents.			
			Water.	Protein.	Fat.	Ash.
	FIRST TEST.					
495	Fresh meat taken.....	Grams. 397.8	Grams. 298.6	Grams. 87.6	Grams. 6.8	Grams. 4.3
493 497	} Same broiled 15 minutes.....	266.7	174.5	81.1	6.9	3.9
	Loss (—) or (apparent) gain (+)	—131.1	—124.1	—6.5	+1.1	— .4
	SECOND TEST.					
496	Fresh meat taken.....	364.9	274.3	79.9	6.4	4.1
494 498	} Same broiled 15 minutes.....	250.4	160.6	79.0	6.4	3.8
	Loss (—) or (apparent) gain (+)	—114.5	—113.7	— .9	.0	— .3

The following table shows the percentage of the loss in total weight and the loss of the different constituents in percentages of the total weight of the uncooked meat. The percentage loss of each constituent in the uncooked meat is also shown.

TABLE 15.—*Percentage losses in lean beef during the process of pan-broiling.*

Experiment.		Sample No.	Total loss and loss of different constituents in percentages of total weight of uncooked meat.					Loss of different constituents in percentages of total amounts in uncooked meat.			
No.	Description.		Total weight.	Water.	Protein.	Fat.	Ash.	Water.	Protein.	Fat.	Ash.
			<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>
1	Broiled 20 minutes ...	398	—35.1	—35.2	+0.4	+0.1	—0.1	—46.8	+2.1	+2.8	—11.8
1	Broiled 15 minutes ...	399	—28.5	—28.5	+ .3	t	— .1	—38.1	+1.3	t	— 6.7
2	Broiled 17 minutes ...	408	—23.1	—24.5	+1.4	+ .1	t	—33.7	+6.2	+2.4	+ 3.8
2	do	409	—24.1	—25.1	+ .7	+ .1	— .1	—34.1	+3.3	+2.4	—11.1
3	do	416	—33.5	—33.3	— .2	+ .2	— .1	—44.6	— .9	+8.7	— 8.3
3	do	417	—30.5	—30.4	+ .1	t	t	—40.7	+ .2	t	t
12	Broiled 15 minutes ...	497	—33.0	—31.2	—1.6	t	— .1	—41.6	—7.4	+1.5	— 9.3
12	do	498	—31.4	—31.2	— .2	t	— .1	—41.5	—1.1	t	— 7.3
	Average		—29.9	—29.9	+ .1	+ .1	— .1	—40.1	+ .5	+2.2	— 6.3

t Trace, less than 0.05 per cent loss or (apparent) gain.

DISCUSSION OF LOSSES BY PAN-BROILING.

From the results in the tables above it will be observed that there was a loss of water in every case, the amount lost depending upon the time and temperature of the cooking. The removal of the visible fat before cooking left the meat so lean that little fat cooked out of it. For this reason, and because no fat was added in broiling, some of the samples were slightly charred on the exterior during the cooking. The loss in ash was probably due to the fact that the juices of the meat holding the mineral constituents in solution exuded and spread over the bottom of the pan, and as the water evaporated from them the mineral constituents were left clinging to the pan in such a condition that they could not be readily and completely removed by scraping.

According to some of the results in the above tables there appear to be slight gains in the amounts of nutrients in the meat after cooking.

It is plainly evident, however, that cooking according to the method followed in the experiments can not add any nutritive material to the meat. The apparent gains may perhaps be due to (1) slight differences in chemical methods of manipulation in the analyses of the uncooked and the cooked meats; (2) incomplete extraction of nitrogen in the analyses of the uncooked meat; (3) a greater loss of fat in the slow process of partial drying of the uncooked meat than in the partial drying of the cooked meat after the coagulation and rapid drying by frying; (4) incomplete determination of water in the cooked sample.

The average of the results of all four experiments indicates that the percentage of loss of nutritive material by this method of cooking is inconsiderable.

LOSSES IN MEATS COOKED BY BOILING AND STEWING.

In the experiments just described the cuts of meat were finely ground and thoroughly mixed so that it was possible to get two samples of the same cut of meat that were at least approximately alike in composition; therefore the losses in cooking could be determined by comparing the analysis of a raw sample with that of a cooked sample. In the following experiments on the losses in meat cooked by boiling, however, the meat was cooked in pieces weighing from 1 to 5 pounds. In this case the losses could not be determined by comparing the composition of the cooked meat with that of the raw meat, because, even when the greatest care is observed in selecting, it is practically impossible to secure two pieces that are even approximately alike in composition.

COMPOSITION OF ALTERNATE PORTIONS OF THE SAME CUT OF BEEF.

In order to test this a cut of lean beef round, weighing about 18 pounds, was selected and the visible fat removed as completely as possible. The lean meat was then cut into eight portions, weighing about 2 pounds each. Judging by appearances, the different portions were very similar. The first, third, fifth, and seventh portions were prepared for analysis by grinding and drying as usual, while the second, fourth, sixth, and eighth were used for cooking experiments Nos. 4 and 5 hereafter described. The results of the analyses of the four portions of the uncooked meat are given in the following table:

TABLE 16.—*Analyses of four alternate portions of the same cut of beef.*

Laboratory No.	Sample.	Composition of fresh material.					Composition of water-free substance.			
		Water.	Protein.	Fat.	Ash.	Total.	Protein.	Fat.	Ash.	Total.
427.....	Beef round	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>
428.....	do.....	73.84	21.53	3.46	1.09	99.92	82.29	13.24	4.16	99.69
429.....	do.....	73.97	22.39	2.71	1.12	100.19	86.02	10.39	4.31	100.72
430.....	do.....	72.88	23.09	2.89	1.25	100.11	85.14	10.65	4.60	100.39
		72.56	22.80	3.42	1.12	99.90	83.10	12.50	4.06	99.66

The results in the preceding table indicate that uniform samples of a cut of meat can not be secured by the method followed. The protein in the water-free substance ranges from 82 to 86 per cent and the fat from 10 to 13 per cent in the different portions. In the course of the investigations reported in this bulletin the above test was repeated a number of times, and in all cases the results were similar to those given here. That is, it was found quite impossible to take two or more portions of the same cut of meat which would be sufficiently alike in composition for use in determining the losses involved in the boiling of meat by comparing the composition of one portion raw with that of another portion cooked. The difference in composition of the different portions may be due to a variation in the amount of invisible fat distributed throughout the muscular fiber. Whatever the cause of variation, the results indicate that the method is not satisfactory.

GENERAL PLAN OF THE EXPERIMENTS.

A number of experiments were carried out, therefore, to devise a suitable method of investigating the losses involved in boiling meat. The piece of meat was weighed before and after cooking, and the difference was taken as the total loss in weight and for convenience has been designated as "broth." This loss consisted partly of water and partly of nutritive ingredients contained in the broth. The broth was analyzed and the amounts of protein, fat, and mineral matters in it were determined. The sum of these ingredients in the broth was subtracted from the total loss in weight and the difference was taken as water cooked out of the meat. The cooked meat itself was then analyzed, and the amount of each ingredient in the cooked meat was added to that in the broth and the sum taken as the amount of the ingredients in the raw meat. From this amount and the amount in the broth the percentage of loss of the ingredients was calculated. As pointed out elsewhere, the material removed in the broth is an actual loss only when the broth is not utilized.

In the first of the following experiments the broths were evaporated to dryness at a low temperature upon the water bath, and were finally dried in a water oven at about 65° C. This was a slow process, and the residue obtained was very gelatinous and sticky, and, therefore, difficult to sample and analyze. In experiments Nos. 4, 5, and 6 the water, protein, fat, and ash were determined in the broth residues obtained in this way, but the results were not satisfactory. In later experiments, therefore, it was decided to first filter the broth, then determine the volume of the filtered broth and its composition, and finally the weight and composition of the residues on the filter paper. In the experiments after No. 6 both the proteid and the nonproteid nitrogen in the broths were determined by the method previously mentioned (see p. 13).

Several of the experiments were made in such a way as to determine what amount, if any, of the nutrients were volatilized during different methods of cooking.

For each of the experiments there are two tables of data. The first table gives the composition of the fresh material and the water-free substance of the cooked meat and the broth. In several experiments the composition of a similar portion of uncooked meat is given also, but is not used in calculating the results of the experiments, because, as already explained, the two portions are not sufficiently alike in composition for an accurate determination of the losses by comparing the composition of the portion that is not cooked with that of the portion that is cooked.

The second table gives the total weight of the cooked meat and the broth and the weights of the ingredients in them. In the case of the cooked meat all the ingredients are calculated directly by the use of the figures for composition given in the first table. In the case of the broth, the protein, fat, and ash are calculated by the figures for composition given in the first table. The sum of these three ingredients is subtracted from the total loss in weight of the meat, and the difference taken as water cooked out of the meat.

EXPERIMENT No. 4.

The pieces of meat used in this experiment were alternate portions (the second and fourth) of the cut of meat used in the comparison of the composition of separate portions, as previously described (p. 20). Each piece of meat was placed separately in 1,500 cubic centimeters of boiling water and the water kept very near the boiling point for ten minutes. The temperature was then gradually reduced to 80° C., and the meat was cooked for two hours and twenty minutes at a temperature of 80° to 85° C. It was then removed from the water, allowed to drain and cool, and finally weighed. The broth from each piece of meat was evaporated to dryness upon a water bath, then dried in a water oven at 65° C., sampled, and analyzed.

The weight of the fresh lean meat used in the first test was 1,082.2 grams, and the weight of the same meat cooked (No. 423) was 667.2 grams. The loss in weight from cooking was 415 grams, equivalent to 38.3 per cent of the original weight of the meat. Of this loss there were 15.9 grams of protein, 2.7 grams of fat, and 5.2 grams of ash. The sum of these subtracted from the total loss in weight gives 391.2 grams as the amount of water lost, which was equivalent to 36.1 per cent of the original weight of the meat.

In order to illustrate the inaccuracy of the results that would be obtained if the losses in cooking were determined by comparing the composition of a portion of meat after it is cooked in this way with that of a similar portion uncooked, it will be interesting to calculate the amounts of ingredients in sample No. 423 before cooking by use

of the composition of sample No. 427, which was analyzed raw, as these two pieces of meat were adjoining portions of the same cut and, judging by appearances, were as nearly alike as possible.

According to the analysis of sample No. 427, given in the first table of this experiment, the 1,082 grams of sample No. 423 before cooking would contain: Water, 799; protein, 233; fat, 37, and ash, 12 grams; and if these figures were compared with those of the ingredients in sample No. 423 after cooking, the loss would be indicated as: Water, 396; protein, 3; fat, 13, and ash, 5 grams. Determined directly by analysis of the broth from sample No. 423, however, the loss was found to be: Water, 391; protein, 16; fat 3, and ash, 5 grams. The differences in the losses estimated both ways are doubtless due to the fact that the two portions of meat from which the above samples were taken, although cut side by side from the same piece of meat and apparently alike, differed considerably in composition.

The weight of the fresh lean meat used in the second test was 1,064.9 grams, and the weight of the same cooked (No. 424) was 627.6 grams. The loss in weight from cooking was 437.3 grams, equivalent to 41.0 per cent of the original weight of meat. The loss of water was 410.6 grams, equivalent to 38.6 per cent of the original weight of meat.

The following tables contain the data of the experiment:

TABLE 17.—*Composition of broth residue and of uncooked and cooked lean beef (cooking experiment No. 4).*

Laboratory No.	Sample.	Composition of fresh material.					Composition of water-free substance.			
		Water.	Protein.	Fat.	Ash.	Total.	Protein.	Fat.	Ash.	Total.
		<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>
427	Uncooked beef.....	73.84	21.53	3.46	1.09	99.92	82.29	13.24	4.16	99.69
423	Cooked beef.....	60.42	34.53	3.72	1.10	99.77	87.24	9.40	2.78	99.42
432	Broth residue.....	7.25	61.82	10.71	20.22	100.00	66.65	11.54	21.81	100.00
428	Uncooked beef.....	73.97	22.39	2.71	1.12	100.19	86.02	10.39	4.31	100.72
424	Cooked beef.....	58.66	37.50	2.85	1.01	100.02	90.73	6.89	2.45	100.07
433	Broth residue.....	6.03	54.32	19.31	20.34	100.00	57.81	20.53	21.66	100.00

TABLE 18.—*Total amounts of constituents in broth from lean beef cooked in water, with amounts in the cooked meat (experiment No. 4).*

Laboratory No.	Sample.	Total weight of material.	Weight of constituents.			
			Water.	Protein.	Fat.	Ash.
		<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>
FIRST TEST.						
423	Cooked meat.....	a 667.2	403.1	230.4	24.8	7.3
432	Broth.....	a(415.0)	b(391.2)	15.9	2.7	5.2
	Total in meat taken.....	1,082.2	794.3	246.3	27.5	12.5
SECOND TEST.						
424	Cooked meat.....	627.6	368.1	235.4	17.9	6.3
433	Broth.....	a(437.3)	b(410.6)	15.4	5.5	5.8
	Total in meat taken.....	1,064.9	778.7	250.8	23.4	12.1

a Determined directly by weighing the meat before and after cooking. The weight of the dried broth residue, when analyzed, was 25.7 grams from 423 and 28.4 grams from 424.

b Determined by subtracting from the total loss in weight the sum of the nutrients found in the broth. The amount of water in the broth, when analyzed, was 1.7 grams from 423 and 1.7 grams from 424.

EXPERIMENT No. 5.

The two pieces of meat used in this experiment were the remaining alternate portions (the sixth and the eighth) of the meat used for studying the comparative composition as previously described. The method of the experiment, including the cooking (boiling), was the same as that of experiment No. 4.

The weight of the fresh lean meat used in the first test was 1,176 grams, and the weight of the same meat when cooked (No. 425) was 760.7 grams. The loss in weight by cooking was 415.3 grams, equivalent to 35.3 per cent of the original weight of the meat. The loss of water was 397.3 grams, equivalent to 33.8 per cent of the original weight of the meat.

The weight of the fresh meat used in the second test was 856 grams, and the weight of the same meat cooked (No. 426) was 564.7 grams. The loss in weight was 291.3 grams, equivalent to 34 per cent of the original weight of the meat. The loss of water was 272.9 grams, equivalent to 31.9 per cent of the original weight of the meat.

The following tables contain the data of the experiment:

TABLE 19.—Composition of broth residue and of uncooked and cooked lean beef (cooking experiment No. 5).

Labora- tory No.	Sample.	Composition of fresh material.					Composition of water-free substance.			
		Water.	Pro- tein.	Fat.	Ash.	Total.	Pro- tein.	Fat.	Ash.	Total.
		<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>
429	Uncooked beef.....	72.88	23.09	2.89	1.25	100.11	85.14	10.65	4.60	100.39
425	Cooked beef.....	57.51	38.17	3.08	1.44	100.20	89.85	7.25	3.40	100.50
434	Broth residue.....	6.87	61.63	9.66	21.84	100.00	66.17	10.37	23.46	100.00
430	Uncooked beef.....	72.56	22.80	3.42	1.12	99.90	83.10	12.50	4.06	99.66
426	Cooked beef.....	58.70	33.59	6.54	1.17	100.00	81.35	15.84	2.83	100.02
435	Broth residue.....	3.19	56.21	2.81	19.79	100.00	58.07	21.48	20.45	100.00

TABLE 20.—Total amounts of constituents in broth from lean beef cooked in water, with amounts in the cooked meat (experiment No. 5).

Labora- tory No.	Sample.	Total weight of material.	Weight of constituents.			
			Water.	Pro- tein.	Fat.	Ash.
	FIRST TEST.	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>
425	Cooked meat.....	760.7	437.5	290.4	23.4	10.9
434	Broth.....	a(415.3)	b(397.3)	11.9	1.9	4.2
	Total in meat taken.....	1,176.0	834.8	302.3	25.3	15.1
	SECOND TEST.					
426	Cooked meat.....	564.7	331.5	189.7	36.9	6.6
435	Broth.....	a(291.3)	b(272.9)	10.7	3.9	3.8
	Total in meat taken.....	856.0	604.4	200.4	40.8	10.4

a Determined directly by weighing the meat before and after cooking. The weight of the dried broth residue when analyzed was 19.4 grams from 425 and 19.0 grams from 426.
b Determined by subtracting from the total loss in weight the sum of the nutrients found in the broth. The amount of water in the broth, when analyzed, was 1.3 grams from 424 and 0.6 gram from 426.

EXPERIMENT No. 6.

In this experiment two similar pieces of the same cut of meat were selected and all visible fat was removed. Instead of placing the meat immediately in boiling water, as in experiments Nos. 4 and 5, each piece was placed in 2,000 cubic centimeters of cold distilled water and the temperature was gradually increased to 83° C. The meat was cooked for four hours and thirty-five minutes at a temperature of 83° to 89° C., and was then removed and allowed to drain and cool, and finally was weighed and prepared for analysis as usual.

The weight of the fresh lean meat used in the first test was 1,623.5 grams, and the weight of the same meat cooked (No. 437) was 906 grams. The loss in weight was 717.5 grams, equivalent to 44.2 per cent of the original weight of the meat. The loss of water was 687.6 grams, equivalent to 42.3 per cent of the original weight of the meat. The volume of the broth was 1,000 cubic centimeters. The nitrogen was determined in the unfiltered broth and was considered to be all in the form of flesh bases ($N \times 3.12$). In view of results obtained in later experiments, it is probable that there is a slight error introduced by this assumption.

The weight of the fresh lean meat used in the second test was 1,119.8 grams, and the weight of the same meat cooked (No. 438) was 619.2 grams. The loss in weight was 500.6 grams, equivalent to 44.7 per cent of the original weight of the meat. The loss of water was 481.5 grams, equivalent to 43 per cent of the original weight of the meat. The volume of the broth was 1,000 cubic centimeters. The nitrogen was determined as above.

The following tables contain the data of the experiment:

TABLE 21.—Composition of broth and of uncooked and cooked lean beef (cooking experiment No. 6).

Laboratory No.	Sample.	Composition of fresh material.					Composition of water-free substance.			
		Water.	Protein.	Fat.	Ash.	Total.	Protein.	Fat.	Ash.	Total.
		<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>
439	Uncooked beef.....	73.65	22.65	1.94	1.15	99.39	86.15	7.37	4.35	97.87
437	Cooked beef	58.72	35.94	2.43	1.31	98.40	87.05	7.69	3.17	97.89
448	Broth (1 liter)	<i>a</i> (97.01)	<i>b</i> (1.28)	.77	.94	100.00	.....	.....	.....	.....
442	Uncooked beef.....	73.69	21.44	3.00	1.10	99.23	81.51	11.39	4.18	97.08
438	Cooked beef	58.69	35.59	3.46	1.00	98.74	86.15	8.38	2.41	96.94
449	Broth (1 liter)	<i>a</i> (98.09)	<i>b</i> (.87)	.39	.65	100.00	.....	.....	.....	.....

a Water not determined directly, but estimated by difference.

b Nitrogen assumed as all in the form of flesh bases and computed as $N \times 3.12$.

TABLE 22.—*Total amounts of constituents in broth from lean beef cooked in water, with amounts in the cooked meat (experiment No. 6).*

Laboratory No.	Sample.	Total weight of material.	Weight of constituents.			
			Water.	Protein.	Fat.	Ash.
	FIRST TEST.					
437	Cooked meat.....	Grams. 906.0	Grams. 532.0	Grams. 325.6	Grams. 22.0	Grams. 11.9
448	Broth	a (717.5)	b (687.6)	12.8	7.7	9.4
	Total in meat taken	1,623.5	1,219.6	338.4	29.7	21.3
	SECOND TEST.					
438	Cooked meat.....	619.2	363.4	220.4	21.4	6.2
449	Broth	a (500.6)	b (481.5)	8.7	3.9	6.5
	Total in meat taken	1,119.8	844.9	229.1	25.3	12.7

a Determined directly by weighing the meat before and after cooking. The weight of the dried broth residue when analyzed was 29.9 grams from 437 and 19.1 grams from 438.

b Determined by subtracting from the total loss in weight the sum of the nutrients found in the broth.

EXPERIMENT No. 7.

In this experiment two pieces of lean beef (round) were selected and all visible fat was removed. Each piece of meat was placed directly into 2,000 cubic centimeters of boiling distilled water, an amount which was just enough to cover the meat completely. The water was kept boiling for ten minutes, and then the temperature was lowered to 85° C., and the meat was cooked at this temperature for two hours and twenty minutes. It was then removed and allowed to drain and cool, after which it was weighed. The resulting broth was cooled, filtered, and the volume measured.

The weight of the fresh lean meat used in the first test was 758 grams, and the weight of the same meat cooked (No. 450) was 490.5 grams. The loss in weight was 267.5 grams, equivalent to 35.3 per cent of the original weight of the meat. The loss of water was 254.3 grams, equivalent to 33.5 per cent of the original weight of the meat. The volume of the broth was 2,250 cubic centimeters.

The weight of the fresh lean meat used in the second test was 888.9 grams, and the weight of the same meat cooked (No. 453) was 517.3 grams. The loss in weight was 371.6 grams, equivalent to 41.8 per cent of the original weight of the meat. The loss of water was 356.2 grams, equivalent to 40.1 per cent of the original weight of the meat. The volume of the broth was 2,250 cubic centimeters.

The following tables contain the data of the experiment:

TABLE 23.—Composition of broth and of uncooked and cooked lean beef (cooking experiment No. 7).

Lab- ora- tory No.	Sample.	Composition of fresh material.						Composition of water-free substance.			
		Water.	Pro- tein, N×6.25.	Flesh bases, N×3.12.	Fat.	Ash.	Total.	Pro- tein.	Fat.	Ash.	Total.
		<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>
451	Uncooked beef	71.84	22.25		4.89	1.13	100.11	79.03	17.38	4.02	100.43
450	Cooked beef...	56.00	35.21		8.37	.95	100.53	80.02	19.02	2.15	101.19
456	Broth (1 liter)...	<i>a</i> (99.41)	0.02	0.28	.09	.20	100.00	.....	.....	.....	.....
454	Uncooked beef	71.19	22.76		5.40	1.08	100.43	79.02	18.75	3.74	101.51
453	Cooked beef...	55.74	34.29		9.12	.95	100.10	77.48	20.60	2.14	100.22
458	Broth (1 liter)...	<i>a</i> (99.32)	.10	.27	.10	.22	100.00	.....	.....	.....	.....

a Water not determined directly, but estimated by difference.

TABLE 24.—Total amounts of constituents in broth from lean beef cooked in water, with amounts in the cooked meat (experiment No. 7).

Labo- ratory No.	Sample.	Total weight of material.	Weight of constituents.				
			Water.	Nitrogenous matter.		Fat.	Ash.
				Pro- teids.	Flesh bases.		
	FIRST TEST.	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>
450	Cooked meat	490.5	274.7	172.7		41.1	4.7
456	Broth.....	<i>a</i> (267.5)	<i>b</i> (254.3)	0.4	6.3	2.0	4.5
	Total in meat taken.....	758.0	529.0	179.4		43.1	9.2
	SECOND TEST.						
453	Cooked meat	517.3	288.4	177.4		47.2	4.9
458	Broth.....	<i>a</i> (371.6)	<i>b</i> (356.2)	2.3	6.0	2.2	4.9
	Total in meat taken.....	888.9	644.6	185.7		49.4	9.8

a Determined directly by weighing the meat before and after cooking. The weight of the dried broth residue when analyzed was 13.2 grams from 450 and 15.4 grams from 453.

b Determined by subtracting from the total loss in weight the sum of the nutrients found in the broth.

EXPERIMENT No. 8.

In order to ascertain whether all the material cooked out of the meat is contained in the broth in the following experiment, the meat was cooked in an apparatus arranged for collecting any volatile products that might pass off. For this purpose use was made of a large iron starch digester, which was connected with a Liebig condenser. This, in turn, was connected with a stoppered, wide-mouthed, empty bottle for collecting any volatile compounds that might become condensed. This bottle was further connected with a Drechsel wash bottle containing concentrated sulphuric acid, which would retain any volatile organic compounds that were not condensed. The entire apparatus was tested and found to be air-tight.

The lean beef round selected for this experiment was placed in the iron digester in 2,000 cubic centimeters of boiling distilled water. The vessel was then tightly closed and connected with the apparatus

for collecting volatile products. A temperature of 98°–99° C. was maintained for ten minutes and was then allowed to drop to 98°. The meat was cooked at this temperature for two hours and twenty minutes, and was then removed, drained and cooled, and weighed. Some perfectly clear water had condensed in the bottle which was empty at the beginning of the experiment. This water was transferred to a Kjeldahl digestion flask, sulphuric acid was added, and the analysis completed as usual. The results showed that no nitrogenous substance was present in the water. The sulphuric acid in the Drechsel wash bottle, through which the gases passed as they were driven out of the closed vessel, was put into a digestion flask, metallic mercury added, and the analysis completed as usual. No nitrogen was found. The experiment, therefore, indicates that no nitrogenous matter was volatilized during the process of boiling the meat.

The weight of the fresh lean meat used in this test was 863.4 grams, and the weight of the same meat cooked (No. 452) was 473 grams. The loss in weight by cooking was 390.4 grams, equivalent to 45.2 per cent of the original weight of the meat. The loss in water was 374.7 grams, equivalent to 43.4 per cent of the original weight of the meat. The data concerning the losses in the meat by cooking are given in the following tables. The volume of the broth was 2,280 cubic centimeters.

TABLE 25.—*Composition of broth and of uncooked and cooked lean beef (cooking experiment No. 8).*

Lab- ora- tory No.	Sample.	Composition of fresh material.						Composition of water-free substance.			
		Water.	Protein, N×6.25.	Flesh bases, N×3.12.	Fat.	Ash.	Total.	Pro- tein.	Fat.	Ash.	Total.
		<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>
454	Uncooked beef ...	71.19	22.76		5.40	1.08	100.40	79.02	18.75	3.74	100.51
452	Cooked beef	55.64	39.22		4.56	.96	100.38	88.42	10.27	2.16	100.85
457	Broth (1 liter)....	a (99.31)	0.05	0.33	.06	.25	100.00	-----	-----	-----	-----

a Water not determined directly, but estimated by difference.

TABLE 26.—*Total amounts of constituents in broth from lean beef cooked in water, with amounts in the cooked meat (experiment No. 8).*

Laboratory No.	Sample.	Total weight of material.	Weight of constituents.				
			Water.	Nitrogenous matter.		Fat.	Ash.
				Proteids.	Flesh bases.		
		<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>
452	Cooked meat	473.0	263.2	185.5	21.5	4.5	
457	Broth.....	a (390.4)	b (374.7)	1.1	7.3	1.5	5.8
	Total in meat taken.....	863.4	637.9	193.9	23.0	10.3	

a Determined directly by weighing the meat before and after cooking. The weight of the dried broth residue, when analyzed, was 15.7 grams.

b Determined by subtracting from the total loss in weight the sum of the nutrients found in the broth.

EXPERIMENT No. 9.

This experiment was carried out in such a way that it was possible to estimate the losses in boiling meats both by the method followed in the other experiments and by comparing the composition of a sample of raw meat with that of a corresponding sample of cooked meat. A piece of round steak was obtained, all the visible fat was removed, and the lean meat was passed three times through a sausage mill, with intimate mixture of the ground meat each time. Of the homogeneous mixture one sample was retained for analysis of the raw meat and another for cooking. The sample to be cooked was pressed firmly together with the hands and placed in 1,000 cubic centimeters of boiling distilled water. The water was allowed to boil for ten minutes after which 500 cubic centimeters of cold distilled water was added, which reduced the temperature to 67° C. The temperature was then allowed to increase to 80° and maintained for two hours.

The weight of the fresh lean meat taken for cooking was 442 grams, and the weight of the same meat cooked (No. 459) was 282.9 grams. The loss in weight by cooking was 159.1 grams, equivalent to 36 per cent of the original weight of the meat. The amount of water lost in cooking was 152.7 grams, equivalent to 34.6 per cent of the original weight of the meat. The volume of the broth was 1,500 cubic centimeters.

The amounts of ingredients in the meat before it was cooked have been estimated in the usual way by adding the amounts found in the cooked meat to those found in the broth. This gave water 318.5, nitrogenous matter 88.5, fat 28.5, and ash 5 grams. If the composition of the sample analyzed raw (No. 461), given in the first table of the experiment, be used for computing the amounts of ingredients in the 442 grams of the meat taken for cooking, the result is: Water 315.7, nitrogenous matter 90.5, fat 28, and ash 4.7 grams. These figures are practically identical with those obtained in the usual way.

The method followed in this experiment was not adopted in the investigations because in household practice it is not usual to grind meat that is to be cooked in water; and the purpose of the investigations was to determine the losses that are involved in the ordinary household methods of preparing meat. The experiment is especially valuable, since it indicates the reliability of the results that have been obtained by the method adopted.

The data of the experiment are given in the following tables:

TABLE 27.—*Composition of broth and of uncooked and cooked lean beef (cooking experiment No. 9).*

Laboratory No.	Sample.	Composition of fresh material.						Composition of water-free substance.			
		Water.	Protein, N×6.25.	Flesh bases, N×3.12.	Fat.	Ash.	Total.	Protein.	Fat.	Ash.	Total.
		<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>
461	Uncooked beef...	71.44	20.48		6.34	1.06	99.32	71.72	22.19	3.71	97.62
459	Cooked beef.....	58.60	30.05		9.86	.97	99.48	72.58	23.82	2.34	98.74
462	Broth (1 liter)....	<i>a</i> (99.58)	0.05	0.18	.04	.15	100.00				
460	Cooked beef.....	59.63	29.63		9.51	.92	99.69	73.40	23.55	2.27	99.22

a Water not determined directly but estimated by difference.

TABLE 28.—*Total amounts of constituents in broth from lean beef cooked in water, with amounts in the cooked meat (experiment No. 9).*

Laboratory No.	Sample.	Total weight of material.	Weight of constituents.				
			Water.	Nitrogenous matter.		Fat.	Ash.
				Proteids.	Flesh bases.		
		<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>
459	Cooked meat	282.9	165.8	85.0		27.9	2.7
462	Broth.....	<i>a</i> (159.1)	<i>b</i> (152.7)	0.8	2.7	.6	2.3
	Total in meat taken.....	442.0	318.5	88.5		28.5	5.0
461	Same computed directly		315.7	90.5		28.0	4.7

a Determined directly by weighing the meat before and after cooking. The weight of the dried broth residue when analyzed was 6.4 grams.

b Determined by subtracting from the total loss in weight the sum of the nutrients found in the broth.

EXPERIMENT NO. 10.

In this experiment the boiling was carried on in a closed iron vessel attached to the apparatus for collecting any volatile products that might pass off, as described in experiment No. 8. Two pieces of lean beef were used, but in this case the visible fat was not removed. Each piece of meat was placed directly in boiling water, one in 1,500 cubic centimeters and the other in 2,000 cubic centimeters, and both were cooked for three hours at a temperature of 80° C. The meat was then removed from the closed vessel, allowed to drain and cool thoroughly, after which it was weighed and prepared for analysis. Two samples from each piece of cooked meat were analyzed, and the average of the two analyses used in calculating the total amounts of the ingredients in the cooked meat.

The weight of the fresh meat used in the first test was 1,300.2 grams and the weight of the same meat cooked was 713.2 grams. The loss from cooking was 587 grams, equivalent to 45.2 per cent of the original weight of the meat. The loss of water was 505.3 grams, equivalent to 38.9 per cent of the original weight of the meat. The volume of the broth was 1,230 cubic centimeters.

The weight of the fresh meat used in the second test was 1,283.1 grams and the weight of the same cooked was 721 grams. The loss

in cooking was 562.1 grams, equivalent to 43.8 per cent of the original weight of fresh meat. The loss of water was 477.2 grams, equivalent to 37.2 per cent of the original weight of the meat. The volume of the broth was 1,800 cubic centimeters.

As a result of an accident the distillates collected in the empty flask were lost. The sulphuric acid in the wash bottle, however, contained no nitrogen, thus giving the same result in this respect as experiment No. 8.

The following tables contain the data of the experiment:

TABLE 29.—Composition of broth and of cooked lean beef (cooking experiment No. 10).

Lab- ora- tory No.	Sample.	Composition of fresh material.						Composition of water-free substance.			
		Water.	Protein, N×6.25.	Flesh bases, N×3.12.	Fat.	Ash.	Total.	Pro- tein.	Fat.	Ash.	Total.
		<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>
463	Cooked beef.....	50.95	34.42	14.25	0.74	100.36	70.17	29.05	1.51	100.73	
464	do.....	51.06	34.24	14.10	.75	100.15	69.96	28.80	1.52	100.28	
	Average of two..	51.00	34.33	14.17	.74	100.25	70.06	28.93	1.51	100.51	
471	Broth (1 liter)...	a (93.35)	0.47	0.67	4.91	.60	100.00				
465	Cooked beef.....	51.42	32.75	15.49	.75	100.41	67.42	31.89	1.55	100.86	
466	do.....	51.33	32.72	15.52	.68	100.25	67.58	31.88	1.40	100.86	
	Average of two..	51.37	32.73	15.51	.72	100.33	67.50	31.88	1.48	100.86	
472	Broth (1 liter)...	a (95.29)	.27	.60	3.45	.39	100.00				

a Water not determined directly, but estimated by difference.

TABLE 30.—Total amounts of constituents in broth from lean beef cooked in water, with amounts in the cooked meat (experiment No 10).

Labora- tory No.	Sample.	Total weight of material.	Weight of constituents.				
			Water.	Nitrogenous matter.		Fat.	Ash.
				Pro- teids.	Flesh bases.		
471	FIRST TEST.						
	Cooked meat (average, 463 and 464).....	<i>Grams.</i> 713.2	<i>Grams.</i> 363.7	<i>Grams.</i> 244.8	<i>Grams.</i> 101.1	<i>Grams.</i> 5.3	
	Broth.....	<i>a</i> (587.0)	<i>b</i> (505.3)	5.7	8.2	60.4	7.4
	Total in meat taken	1,300.2	869.0	258.7	161.5	12.7	
	SECOND TEST.						
472	Cooked meat (average, 465 and 466).....	721.0	369.9	235.7	111.7	5.2	
	Broth.....	<i>a</i> (562.1)	<i>b</i> (477.2)	4.9	10.9	62.1	6.9
	Total in meat taken	1,283.1	847.1	251.5	173.8	12.1	

a Determined directly by weighing the meat before and after cooking. The weight of the dried broth residue when analyzed was 81.7 grams in 471 and 84.9 grams in 472.
b Determined by subtracting from the total loss in weight the sum of the nutrients found in the broth.

EXPERIMENT NO. 11.

This experiment was for the most part similar to experiment No. 6. In this case, however, the visible fat was not removed from the lean beef used. One piece of meat was cooked in 1,000 cubic centimeters of distilled water and the other piece in 1,500 cubic centimeters. In each case the meat was placed directly in cold water and the temper-

ature was gradually raised to 85° C., at which the meat was cooked for four hours and thirty-five minutes. Two samples from each piece of the cooked meat were analyzed and the average of the two was used in calculating the total amounts of the ingredients in the cooked meat.

The weight of the fresh meat used in the first test was 1,222.5 grams, and the weight of the same meat cooked 684.5 grams. The loss in weight was 538 grams, equivalent to 44 per cent of the original weight of the meat. In this case the loss of water could not be calculated, as owing to an accident the determination of the fat in the broth was not completed. The volume of the broth was 1,230 cubic centimeters.

The weight of the fresh meat used in the second test was 1,461 grams, and the weight of the same meat cooked 963.3 grams. The loss in weight was 497.7 grams, equivalent to 34.1 per cent of the original weight of the meat. The loss of water was 473.4 grams, equivalent to 32.4 per cent of the weight of the meat. The volume of the broth was 2,050 cubic centimeters.

The following tables contain the data of the experiment:

TABLE 31.—Composition of broth and of cooked lean beef (cooking experiment No. 11).

Lab- ora- tory No.	Sample.	Composition of fresh material.						Composition of water-free substance.			
		Water.	Protein, N×6.25.	Flesh bases, N×3.12.	Fat.	Ash.	Total.	Pro- tein.	Fat.	Ash.	Total.
		<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>
467	Cooked beef.....	51.99	33.57		14.25	0.81	100.62	69.90	29.69	1.69	101.28
468	do.....	51.52	33.74		14.41	.78	100.45	69.58	29.71	1.60	100.89
	Average of two..	51.75	33.67		14.33	.79	100.53	69.74	29.70	1.64	101.08
473	Broth (1 liter)...		0.26	0.58		.51					
469	Cooked beef.....	49.96	27.80		21.55	.72	100.03	55.55	43.07	1.45	100.07
470	do.....	46.70	29.33		23.34	.78	100.15	55.01	43.79	1.46	100.25
	Average of two..	48.33	28.56		22.45	.75	100.09	55.28	43.43	1.45	100.16
474	Broth (1 liter)...	<i>a</i> (98.81)	.23	.34	.29	.33	100.00				

a Water not determined directly, but estimated by difference.

TABLE 32.—Total amounts of constituents in broth from lean beef cooked in water, with amounts in the cooked meat (experiment No. 11).

Labo- ratory No.	Sample.	Total weight of material.	Weight of constituents.				
			Water.	Nitrogenous matter.		Fat.	Ash.
				Pro- teids.	Flesh bases.		
	FIRST TEST.						
473	Cooked meat (average 467 and 468) ...	<i>Grams.</i> 684.5	<i>Grams.</i> 354.2	<i>Grams.</i> 230.5	<i>Grams.</i> 98.1	<i>Grams.</i> 5.4	<i>Grams.</i> 6.7
	Broth.....	<i>a</i> (538.0)		3.3	7.6		
	Total in meat taken.....	1,222.5		241.4			12.1
	SECOND TEST.						
474	Cooked meat (average 469 and 470) ...	963.3	465.5	275.1		216.3	7.2
	Broth.....	<i>a</i> (497.7)	<i>b</i> (473.4)	4.7	7.0	5.9	6.7
	Total in meat taken.....	1,461.0	938.9	286.8		222.2	13.9

a Determined directly by weighing the meat before and after cooking. The weight of the dried broth residue when analyzed was 24.3 grams in 474.

b Determined by subtracting from the total loss in weight the sum of the nutrients found in the broth.

EXPERIMENT No. 13.

In this experiment a cut of lean beef round was divided into two equal portions, from which all bone and gristle were removed, but the visible fat was not removed. Each piece of meat was placed in 2,000 cubic centimeters of boiling distilled water, and the water kept very near to boiling for ten minutes. The temperature was then allowed to fall to 80° C., at which the meat was cooked for two hours.

The weight of the fresh meat used in the first test was 2,580 grams, and the weight of the same meat cooked (No. 714) was 1,845 grams. The loss from cooking was 735 grams, equivalent to 28.5 per cent of the original weight of the meat. The loss of water was 707.4 grams, equivalent to 27.4 per cent of the original weight of the meat. The volume of the broth was 2,390 cubic centimeters.

The weight of the fresh meat used in the second test was 2,180 grams, and the weight of the same meat cooked (No. 715) was 1,400 grams. The loss from cooking was 780 grams, equivalent to 35.8 per cent of the original weight of the meat. The loss of water was 753.8 grams, equivalent to 34.6 per cent of the original weight of the meat. The volume of the broth was 2,410 cubic centimeters.

The following tables contain the data of the experiment:

TABLE 33.—Composition of broth and of cooked lean beef (cooking experiment No. 13).

Lab- ora- tory No.	Sample.	Composition of fresh material.						Composition of water-free substance.			
		Water.	Pro- tein, N×6.25	Flesh bases, N×3.12.	Fat.	Ash.	Total.	Pro- tein.	Fat.	Ash.	Total.
		<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>
714	Cooked beef	68.39	25.91		5.32	0.96	100.58	81.96	16.82	3.03	101.81
719	Broth (1 liter)	<i>a</i> (98.85)	.09	.47	.23	.36	100.00	.....	.....	.....	.....
715	Cooked beef	59.95	32.60		6.59	1.08	100.22	81.41	16.46	2.69	100.56
720	Broth (1 liter)	<i>a</i> (98.91)	.12	.47	.14	.36	100.00	.....	.....	.....	.....

a Water not determined directly, but estimated by difference.

TABLE 34.—Total amounts of constituents in broth from lean beef cooked in water, with amounts in the cooked meat (experiment No. 13).

Labo- ratory No.	Sample.	Total weight of material.	Weight of constituents.				
			Water.	Nitrogenous matter.		Fat.	Ash.
				Pro- teids.	Flesh bases.		
	FIRST TEST.	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>
714	Cooked meat	1,845.0	1,261.8	478.1		98.1	17.7
719	Broth	<i>a</i> (735.0)	<i>b</i> (707.4)	2.1	11.3	5.5	8.7
	Total in meat taken	2,580.0	1,969.2	491.5		103.6	26.4
	SECOND TEST.						
715	Cooked meat	1,400.0	839.3	456.4		92.2	15.1
720	Broth	<i>a</i> (780.0)	<i>b</i> (753.8)	2.8	11.3	3.3	8.8
	Total in meat taken	2,180.0	1,593.1	470.5		95.5	23.9

a Determined directly by weighing the meat before and after cooking. The weight of the broth residue when analyzed was 27.6 grams from 714 and 26.2 grams from 715.

b Determined by subtracting from the total loss in weight the sum of the nutrients found in the broth.

EXPERIMENT No. 14.

This experiment was very similar to No. 13. The beef was divided into two equal portions, from which the bone and gristle were removed, but not the visible fat. Each piece of meat was placed in 2,000 cubic centimeters of cold distilled water. The temperature was gradually raised, taking one hour and thirty minutes to reach 68° C. The meat was then cooked for four hours at a temperature varying from 65° to 70° C.

The weight of the fresh meat used in the first test was 2,020 grams, and the weight of the same meat cooked (No. 737) was 1,475 grams. The loss from the cooking was 545 grams, equivalent to 27 per cent of the original weight of the meat. The loss of water was 529.1 grams, equivalent to 26.2 per cent of the original weight of the meat. The volume of the broth was 2,560 cubic centimeters.

The weight of the fresh meat used in the second test was 2,870 grams, and the weight of the same meat cooked (No. 738) was 2,145 grams. The loss in cooking was 725 grams, equivalent to 25.3 per cent of the original weight of the meat. The loss of water was 705.3 grams, equivalent to 24.6 per cent of the original weight of the meat. The volume of the broth was 2,390 cubic centimeters.

The following tables contain the data of the experiment:

TABLE 35.—Composition of broth and of cooked lean beef (cooking experiment No. 14)

Lab- ora- tory. No.	Sample.	Composition of fresh material.						Composition of water-free substance.			
		Water.	Pro- tein, N×6.25	Flesh bases, N×3.12.	Fat.	Ash.	Total.	Pro- tein.	Fat.	Ash.	Total.
		Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
737	Cooked beef	65.86	26.78		6.29	1.06	99.99	78.41	18.41	3.10	99.92
742	Broth (1 liter)	a (99.39)	0.13	0.15	.04	.29	100.00				
738	Cooked beef	64.46	26.83		8.06	1.04	100.39	75.50	22.68	2.93	101.11
743	Broth (1 liter)	a (99.18)	.19	.21	.04	.38	100.00				

a Water not determined directly, but estimated by difference.

TABLE 36.—Total amounts of constituents in broth from lean beef cooked in water, with amounts in the cooked meat (experiment No. 14).

Labora- tory No.	Sample.	Total weight of material.	Weight of constituents.				
			Water.	Nitrogenous matter.		Fat.	Ash.
				Pro- teids.	Flesh bases.		
	FIRST TEST.						
737	Cooked meat	Grams. 1,475.0	Grams. 971.4	Grams. 395.0		Grams. 92.8	Grams. 15.6
742	Broth.....	a (545.0)	b (529.1)	3.4	3.9	1.1	7.5
	Total in meat taken.....	2,020.0	1,500.5	402.3		93.9	23.1
	SECOND TEST.						
738	Cooked meat	2,145.0	1,382.7	575.5		172.9	22.3
743	Broth.....	a (725.0)	b (705.3)	4.5	4.9	1.1	9.1
	Total in meat taken.....	2,870.0	2,088.0	584.9		174.0	31.4

a Determined directly by weighing the meat before and after cooking. The weight of the broth residue when analyzed was 15.9 grams from 737 and 19.7 grams from 738.

b Determined by subtracting from the total loss in weight the sum of the nutrients found in the broth.

EXPERIMENTS MADE DURING 1899-1900.

LOSSES IN MEATS COOKED BY BOILING AND STEWING.

The preceding experiments on the losses involved in the boiling of meats were regarded as preliminary work, the chief purpose of which was to devise and perfect suitable methods by which the losses could be accurately determined. In these experiments it was found that in the boiling of meat there was no loss of nutritive material by volatilization, but that all nutrients removed from the meat by cooking in this way pass into the liquor or broth. The losses in meat by boiling may therefore be determined by analyzing the cooked meat and the broth. The sum of the constituents in the cooked meat and in the broth may be taken as the amount of these constituents in the original raw meat. From this and the amount in the broth the percentage loss of each constituent may be computed. It should be noted, however, in this connection, that, strictly speaking, the sum of the constituents in the cooked meat and in the broth as found by the usual analyses does not represent exactly the original composition of the raw meat. The amount of such nitrogenous compounds as creatin, amido compounds, etc., in the broth is considerably larger than might be expected from the amount of raw meat taken. Possibly during the process of cooking there is a decomposition of albumen or other proteid material and a formation of the simpler nitrogenous compounds. There would in such case be an error in assuming that all the nitrogenous bodies found in the broth are contained in the meat in the same compounds.

It is evident that the reliability of the results of the experiments here reported depends upon the accuracy and thoroughness of the analysis of the broths, since the analysis of the cooked meats is comparatively simple. In carrying out these investigations it was necessary to devise methods for analyzing the broths, as few investigations upon the subject were found, and in no case were the methods for the complete chemical analysis of broths well described. As stated on page 21, in the first three of these experiments an attempt was made to evaporate the broths to dryness and analyze the solids. The difficulties of sampling the gelatinous residue prevented good results. This method was therefore rejected and the liquid broth was sampled and analyzed. The important features of the method devised were as follows:

GENERAL PLAN OF THE EXPERIMENTS.

In these experiments all material separated from the meat during the cooking, whether mechanically or by solution, has been considered as loss by cooking, and designated as "broth." However, the broth

is ordinarily utilized in soups or gravies, so that there may be in the end no actual loss or waste.

In analyzing the broth it was found desirable to remove the suspended matter, coarse and fine, by filtration, and to analyze the solid matter and the clear filtrate separately. Various attempts were made to filter the total amount of broth, a Büchner porcelain funnel, a Gooch crucible with paper, the same with asbestos, and an ordinary glass funnel with hardened paper filter being tried in turn, but it was found impracticable by any of these to obtain a clear filtration of the entire amount in a reasonably short time. In each method the pores of the filter appeared to become clogged by the suspended particles of fatty and gelatinous material, rendering the filtration so slow that before it could be completed a separation of solid matter, due to decomposition, took place in the filtrate. As it was impracticable to filter the entire amount of the broth, the alternative seemed to be to filter an aliquot portion for analysis. This method was tried and found to be satisfactory.

Immediately after the meat was cooked the broth was rapidly cooled to 15° C. and strained through a counterpoised piece of cheese cloth, which removed the coarser particles of solid matter and most of the fat, which was solid at this temperature. The coarse residue thus collected was dried, weighed, and analyzed. The drying was done at 100° C. over a weighed glass flask to catch the fat drippings. Complete extraction of the fat was then made in a Soxhlet apparatus. The material left after the extraction of the fat was small in amount and difficult to sample, so that direct determinations of ash could not be made, but after the material was weighed the total amount left was used for the determination of nitrogen by the Kjeldahl method. The amount of ash contained in the residue collected on the cheese cloth must have been very small and has been neglected altogether in the calculations.

The strained broth, which was of fairly homogeneous character, was made up to a definite volume, usually 2,000 cubic centimeters, and thoroughly mixed. Of this quantity portions of 200 cubic centimeters each were filtered through counterpoised hardened filter papers by aid of suction. The fine residue collected on the papers was dried, weighed, and analyzed. As in the case of the coarse residue, the drying was done at 100° C., the fat extraction was made in a Soxhlet apparatus, and the nitrogen determined by the Kjeldahl method. The nitrogen found in these residues was considered as being entirely in the form of proteids ($N \times 6.25$).

By means of blank determinations, in which sugar or some substance containing known quantities of nitrogen was used, it was found that

there was no nitrogen in either the cheese cloth or the filter paper used in filtering the broth.

In the experiments of 1898-99 the total solids in the broth were not determined. In the experiments of 1899-1900 several methods were tried in the endeavor to find one by which the determination of solids could be made in the clear filtered broth without decomposing the nitrogenous constituents. It was found that by the simple method of evaporating on the water bath and drying at 100° C. to constant weight there was no loss of nitrogen, and no change in the amount of albuminoids precipitated by bromin. This fact was proved by evaporating and drying the broth in a Kjeldahl digestion flask placed on a water bath, dissolving the residue in hot water, and determining the total and the albuminoid nitrogen according to the methods described below. The amount of nitrogen thus determined was found to be the same as in the corresponding amount of fresh broth.

To check the results obtained by the ordinary method of drying two other methods were used. In the first method ignited pumice stone, in pieces the size of a pea, was placed in shallow aluminium dishes, moistened with 5 cubic centimeters of water and dried exactly as described in the case of the broth. The dishes were weighed and 5 cubic centimeters of the broth distributed evenly over the pumice. This was partially dried at 70° to 80° C., then 5 cubic centimeters of broth was again added and this in turn partially dried at 70° to 80° C. The drying was then continued for eight hours at 75° C. in a slow current of dry air in a partial vacuum corresponding to 25 inches of mercury. In the other method, 25 cubic centimeters of broth was distributed over a strip of filter paper about 7 by 60 centimeters in size, which had been previously dried and weighed. These strips containing the broth were rolled up and dried in a partial vacuum, as described above for the pumice-stone method. The weighings were made in telescopic tubes to avoid the absorption of moisture from the air. It was found that with careful work these two methods gave results agreeing very closely with those obtained by the ordinary method of evaporating upon the water bath and drying in a water oven until the weight was constant.

In the filtered broth the ether extract, nitrogenous matter, and mineral matters or salts were determined. The determination of the salts was made by igniting the solids to a dull red heat in platinum. The ether extract was determined by distributing 25 cubic centimeters of broth over a strip of fat-free absorbent paper, drying thoroughly, and extracting eight hours with anhydrous ether in a Soxhlet apparatus. A test by the Kjeldahl method showed that there was no nitrogen present in the ether extract thus obtained.

In the analysis of the broth a separation of the proteids from the flesh bases was made according to the bromin method already mentioned (see p. 13).

The sum of the materials determined in the filtered broth was found to be considerably less than the total solids as directly determined. The difference has been designated in the tables as "other substances."¹

EXPERIMENT No. 16.

This experiment was made to determine the influence of the amount of fat upon the losses involved in boiling meat. For this purpose about 8 pounds of beef round, as fat as could be obtained at that time, was divided into two approximately equal parts. Each piece was plunged into sufficient boiling water to completely cover it. The boiling was continued for ten minutes, when the temperature was allowed to drop to 83° C., at which it was maintained for two hours. The cooked meat was underdone and juicy.

The weight of the fresh meat used in the first test was 1,220.3 grams, and the weight of the same meat cooked (No. 892) was 800.1 grams. The loss from cooking was 420.2 grams, equivalent to 34.4 per cent of the original weight of the meat. The loss of water was 388.4 grams, equivalent to 31.8 per cent of the original weight of the meat.

The weight of the fresh meat used in the second test was 1,477.8 grams, and the weight of the same meat cooked (No. 893) was 976.4 grams. The loss from cooking was 502 grams, equivalent to 33.9 per cent of the original weight of the meat. The loss of water was 462 grams, equivalent to 31.3 per cent of the original weight of the meat.

The following tables contain the data of the experiment:

TABLE 37.—Composition of broth and of cooked fat beef (cooking experiment No. 16).

Lab- ora- tory No.	Sample.	Composition of fresh sub- stance.				Composition of water-free substance.			
		Water.	Pro- tein.	Fat.	Ash.	Nitrogenous matter.		Fat.	Ash.
						Pro- teids.	Flesh bases.		
		<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>P. ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>P. ct.</i>
892	Broth (suspended matter).....	.....	.....	.....	.....	10.53	90.40	.....	.....
	Broth (filtered).....	.....	.....	.....	.....	6.12	30.62	9.06	25.7
	Cooked meat.....	51.74	27.55	19.99	0.82	57.08	41.42	1.6	.....
	Broth (suspended matter).....	.....	.....	.....	.....	11.08	88.66	.....	.....
893	Broth (filtered).....	.....	.....	.....	.....	9.60	29.09	8.52	24.2
	Cooked meat.....	52.53	28.23	18.88	.88	59.49	39.60	1.8	.....

¹ See p. 62.

TABLE 38.—*Total amounts of constituents in broth from fat beef cooked in water, with amounts in the cooked meat (experiment No. 16).*

Laboratory No.	Sample.	Total weight of material.	Dry matter directly determined.	Weight of constituents.					
				Water.	Nitrogenous matter.		Fat.	Ash.	Other substances.
					Pro- teids.	Flesh bases.			
892	FIRST TEST.								
	Broth (suspended matter)	Grams. 10.5	Grams. 10.5	Grams. 1.1	Grams. 1.1	Grams. 9.5	Grams. 9.5	Grams. 5.5	Grams. 6.0
	Broth (filtered)	21.2	21.2	1.3	6.5	1.9	5.5	6.0	
	Broth (total)	a(420.2)	31.7	b(388.5)	2.4	6.5	11.4	5.5	6.0
	Cooked meat	800.1	386.1	414.0	220.4	159.9	6.6		
	Total in meat taken.	1,220.3	417.8	802.5	229.3	171.4	12.1		
	SECOND TEST.								
893	Broth (suspended matter)		14.2		1.6		12.6		
	Broth (filtered)		25.3		2.4	7.4	2.2	6.1	7.2
	Broth (total)	a(501.5)	39.5	b(462.0)	4.0	7.4	14.8	6.1	7.2
	Cooked meat	976.3	463.5	512.8	275.6	184.3	8.6		
	Total in meat taken.	1,477.8	503.0	974.8	287.0	199.1	14.7		

a Determined directly by weighing the meat before and after cooking.

b Determined by subtracting from the total broth the total dry matter in the broth.

EXPERIMENT No. 17.

In this experiment a piece of the first cut of beef round, weighing from 6 to 8 pounds, about 3 inches thick, and freshly cut from a whole side, was freed carefully from bone and gristle and most of the visible fat. Two pieces, so far as could be judged alike in texture and fat content, were cut from this large piece and weighed quickly. Each piece was placed in water at 20° C. and the temperature gently raised during forty-five minutes to the boiling point. The boiling was continued ten minutes and cold water was then added to reduce the temperature to 80° C., which temperature was maintained two hours. Sample No. 771a proved to be fatter than No. 771b. The cooked meat was well done. The broth was thick and hard to filter.

The weight of the fresh meat used in the first test was 705.5 grams, and the weight of the same meat cooked (No. 771a) was 415.9 grams. The loss from cooking was 289.6 grams, equivalent to 41.1 per cent of the original weight of the meat. The loss of water was 264.8 grams, equivalent to 37.5 per cent of the original weight of the meat.

The weight of the fresh meat used in the second test was 660.8 grams, and the weight of the same meat cooked (No. 771b) was 388 grams. The loss from cooking was 272.8 grams, equivalent to 41.2 per cent of the original weight of the meat. The loss of water was 246.6 grams, equivalent to 37.3 per cent of the original weight of the meat.

The following tables contain the data of the experiment:

TABLE 39.—Composition of broth and of cooked lean beef (cooking experiment No. 17).

Lab- ora- tory No.	Sample.	Composition of fresh sub- stance.				Composition of water-free substance.			
		Water.	Pro- tein.	Fat.	Ash.	Nitrogenous matter.		Fat.	Ash.
						Pro- teids.	Flesh bases,		
		<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>
771a	Broth (suspended matter).....					23.50		68.83	
	Broth (filtered)					2.14	31.77	4.85	23.34
	Cooked meat.....	63.17	28.38	7.23	0.74	77.06		19.63	2.01
	Broth (suspended matter).....					20.15		75.37	
771b	Broth (filtered).....					3.66	30.29	5.38	23.43
	Cooked meat.....	56.01	34.84	8.50	.85	79.20		19.32	1.93

TABLE 40.—Total amounts of constituents in broth from lean beef cooked in water, with amounts in the cooked meat (experiment No. 17).

Lab- ora- tory No.	Sample.	Total weight of mate- rial.	Dry matter directly deter- mined.	Weight of constituents.					
				Water.	Nitrogenous matter.		Fat.	Ash.	Other sub- stances.
					Pro- teids.	Flesh bases.			
771a	FIRST TEST.								
	Broth (suspended matter).....	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>
	Broth (filtered).....		7.5		1.8		5.1		
			17.3		.4	5.5	.8	4.0	6.6
	Broth (total)	a(289.6)	24.8	b(264.8)	2.2	5.5	5.9	4.0	6.6
	Cooked meat	415.9	153.2	262.7	118.0		30.2	3.1	
	Total in meat taken.	705.5	178.0	527.5	125.7		36.1	7.1	
771b	SECOND TEST.								
	Broth (suspended matter).....		9.6		1.9		7.2		
	Broth (filtered).....		16.6		.6	5.0	.9	3.9	6.2
	Broth (total)	a(272.8)	26.2	b(246.6)	2.5	5.0	8.1	3.9	6.2
	Cooked meat	388.0	198.7	189.3	117.8		28.7	2.9	
	Total in meat taken.	660.8	224.9	435.9	125.3		36.8	6.8	

a Determined directly by weighing the meat before and after cooking.
b Determined by subtracting from the total weight of broth the total dry matter in the broth.

EXPERIMENT No. 18.

This experiment was made in order to determine the influence of the size of the piece of meat cooked upon the losses resulting from the cooking. For this purpose 6 pounds of lean beef round was divided into two unequal parts, one weighing about 1 pound and the other about 5 pounds. These two pieces of unequal size were cooked exactly as described above for experiment No. 16—that is, each piece was plunged into sufficient boiling water to cover it completely. The water was boiled for ten minutes and then the temperature was allowed to drop to 83° C. and was maintained there for two hours. The small sample, No. 894, was well done; the large sample, No. 895, was underdone.

The weight of the fresh meat used in the first test was 433.2 grams and the weight of the same meat cooked (No. 845) was 223 grams. The loss from cooking was 210.2 grams, equivalent to 48.5 per cent of the original weight of the meat. The loss of water was 196.2 grams, equivalent to 45.3 per cent of the original weight of the meat.

The weight of the fresh meat used in the second test was 2,080.6 grams and the weight of the same meat cooked (No. 895) was 1,156.4 grams. The loss from cooking was 924.2 grams, equivalent to 44.4 per cent of the original weight of the meat. The loss of water was 865.2 grams, equivalent to 41.6 per cent of the original weight of the meat.

The following tables contain the data of the experiment:

TABLE 41.—Composition of broth and of cooked lean beef (cooking experiment No. 18).

Lab- ora- tory No.	Sample.	Composition of fresh substance.				Composition of water-free substance.			
		Water.	Pro- tein.	Fat.	Ash.	Nitrogenous matter.		Fat.	Ash.
						Pro- teids.	Flesh bases.		
		<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>
894	Broth (suspended matter)					28.50		71.50	
	Broth (filtered)					4.28	30.54	8.02	25.02
	Cooked meat	59.81	38.56	2.70	0.81	92.12		6.46	1.93
	Broth (suspended matter)					39.81		60.19	
895	Broth (filtered)					4.84	29.94	7.80	24.01
	Cooked meat	59.81	35.83	3.64	.99	89.16		9.04	2.46

TABLE 42.—Total amounts of constituents in broth from lean beef cooked in water, with amounts in the cooked meat (experiment No. 18.)

Lab- ora- tory No.	Sample.	Total weight of ma- terial.	Dry matter directly deter- mined.	Weight of constituents.					
				Water.	Nitrogenous matter.		Fat.	Ash.	Other sub- stances.
					Pro- teids.	Flesh bases.			
894	FIRST TEST.								
		<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>
	Broth (suspended matter)		1.3		0.4		0.9		
	Broth (filtered)		12.7		.5	3.9	1.0	3.2	4.1
	Broth (total)	a(210.2)	14.0	b(196.2)	.9	3.9	1.9	3.2	4.1
	Cooked meat	223.0	89.7	133.3	86.0		6.0	1.8	
	Total in meat taken.	433.2	103.7	329.5	90.8		7.9	5.0	
895	SECOND TEST.								
	Broth (suspended matter)		7.9		3.1		4.8		
	Broth (filtered)		51.1		2.5	15.3	4.0	12.3	17.0
	Broth (total)	a(924.2)	59.0	b(865.2)	5.6	15.3	8.8	12.3	17.0
	Cooked meat	1,156.4	464.8	691.6	414.3		42.1	11.5	
	Total in meat taken.	2,080.6	523.8	1,556.8	435.2		50.9	23.8	

a Determined directly by weighing the meat before and after cooking.
b Determined by subtracting from the total weight of broth the weight of dry matter in the broth.

EXPERIMENT No. 20.

This experiment, No. 20, was conducted as follows: A piece of the first cut of beef round, weighing from 6 to 8 pounds, about 3 inches thick, and freshly cut from the whole side, was freed carefully from bone and gristle and most of the visible fat. Two pieces apparently alike as regards texture and fat content were cut from this large piece and quickly weighed. Each piece was plunged into 1,500 cubic centimeters of rapidly boiling distilled water and boiled vigorously for ten minutes. Cold water was then added until the temperature was reduced to 80° C., which was maintained for two hours. The meat was then removed, suspended over the kettle to drain for ten minutes, weighed, passed quickly through the sausage mill three times, thoroughly mixed each time, and sampled for drying and analyzing. The broth was cooled to 15° C., filtered, and analyzed. The samples were rather small and very well done.

The weight of the fresh meat used in the first test was 825.8 grams, and the weight of the same meat cooked (No. 777a) was 477.3 grams. The loss from cooking was 348.5 grams, equivalent to 42.2 per cent of the original weight of the meat. The loss of water was 320.8 grams, equivalent to 38.9 per cent of the original weight of the meat.

The weight of the fresh meat used in the second test was 739.5 grams, and the weight of the same meat cooked (No. 777b) was 422.5 grams. The loss from cooking was 317 grams, equivalent to 42.9 per cent of the original weight of the meat. The loss of water was 290 grams, equivalent to 39.2 per cent of the original weight of the meat.

The following tables contain the data of the experiment:

TABLE 43.—*Composition of broth and of cooked lean beef (cooking experiment No. 20).*

Lab- ora- tory No.	Sample.	Composition of fresh substance.				Composition of water-free substance.			
		Water.	Pro- tein.	Fat.	Ash.	Nitrogenous matter.		Fat.	Ash.
						Pro- teids.	Flesh bases.		
		<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>
777a	Broth (suspended matter)					6.90		93.10	
	Broth (filtered)					12.89	27.31	13.61	24.60
	Cooked meat	55.56	33.14	10.52	0.88	74.57		23.67	1.98
	Broth (suspended matter)					5.45		94.59	
777b	Broth (filtered)					13.10	28.30	15.62	23.03
	Cooked meat	53.33	34.50	11.51	.91	73.92		24.66	1.95

TABLE 44.—*Total amounts of constituents in broth from lean beef cooked in water, with amounts in the cooked meat (experiment No. 20).*

Lab- ora- tory No.	Sample.	Total weight of mate- rial.	Dry matter directly deter- mined.	Weight of constituents.					
				Water.	Nitrogenous matter.		Fat.	Ash.	Other sub- stances.
					Pro- teids.	Flesh bases.			
777a	FIRST TEST.								
	Broth (suspended matter)	Grams.	Grams.	Grams.	Grams.	Grams.	Grams.	Grams.	Grams.
	Broth (filtered)		7.3		0.5		6.8		
	Broth (total)		20.4		2.6	5.6	2.8	5.0	4.4
	Broth (total)	a(348.5)	27.7	b(320.8)	3.1	5.6	9.6	5.0	4.4
	Cooked meat	477.3	212.1	265.2	158.2		50.2	4.2	
777b	Total in meat taken.	825.8	239.8	586.0	166.9		59.8	9.2	
	SECOND TEST.								
	Broth (suspended matter)		7.1		.4		6.7		
	Broth (filtered)		19.9		2.6	5.6	3.1	4.6	4.0
	Broth (total)	a(317.0)	27.0	b(290.0)	3.0	5.6	9.8	4.6	4.0
	Cooked meat	422.5	197.2	225.3	145.8		48.6	3.8	
	Total in meat taken.	739.5	224.2	515.3	154.4		58.4	8.4	

a Determined directly by weighing the meat before and after cooking.

b Determined by subtracting from the total broth the dry matter in the broth.

EXPERIMENT No. 21.

This experiment was conducted in the same manner exactly as experiment No. 20. Sample No. 779a proved to be considerably fatter than No. 779b. Both samples were small and were very well done.

The weight of the fresh meat used in the first test was 750 grams, and the weight of the same meat cooked (No. 779a) was 402.7 grams. The loss from cooking was 347.3 grams, equivalent to 46.3 per cent of the original weight of the meat. The loss of water was 318.6 grams, equivalent to 42.5 per cent of the original weight of the meat.

The weight of the fresh meat used in the second test was 660.5 grams, and the weight of the same meat cooked (No. 779b) was 351.1 grams. The loss from cooking was 309.4 grams, equivalent to 46.8 per cent of the original weight of the meat. The loss of water was 284.9 grams, equivalent to 43.1 per cent of the original weight of the meat.

The following tables contain the data of the experiment:

TABLE 45.—*Composition of broth and of cooked lean beef (cooking experiment No. 21).*

Lab- ora- tory No.	Sample.	Composition of fresh sub- stance.				Composition of water-free substance.			
		Water.	Pro- tein.	Fat.	Ash.	Nitrogenous matter		Fat.	Ash.
						Pro- teids.	Flesh bases.		
777a	Broth (suspended matter)	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
	Broth (filtered)					5.12		94.63	
	Cooked meat	52.95	37.28	8.98	0.81	14.72	27.21	13.90	23.99
	Broth (suspended matter)					79.23		19.09	1.72
777b	Broth (filtered)					9.57		90.24	
	Cooked meat	54.17	38.61	5.87	.84	14.60	27.17	9.16	22.91
						84.25		12.81	1.83

TABLE 46.—*Total amounts of constituents in broth from lean beef cooked in water, with amounts in the cooked meat (experiment No. 21).*

Lab- ora- tory No.	Sample.	Total weight of mate- rial.	Dry matter directly deter- mined.	Weight of constituents.					
				Water.	Nitrogenous matter.		Fat.	Ash.	Other sub- stances.
					Pro- teids.	Flesh bases.			
779a	FIRST TEST.								
	Broth (suspended matter)	Grams.	Grams.	Grams.	Grams.	Grams.	Grams.	Grams.	Grams.
	Broth (filtered)		8.6		0.4		8.2		
			20.1		3.0	5.5	2.8	4.8	4.0
	Broth (total)	a(347.3)	28.7	b(318.6)	3.4	5.5	11.0	4.8	4.0
	Cooked meat	402.7	189.5	213.2	150.1		36.2	3.3	
779b	Total in meat taken.	750.0	218.2	531.8	159.0		47.2	8.1	
	SECOND TEST.								
	Broth (suspended matter)		5.2		.5		4.7		
	Broth (filtered)		19.3		2.8	5.3	1.8	4.4	5.0
	Broth (total)	a(309.4)	24.5	b(284.9)	3.3	5.3	6.5	4.4	5.0
	Cooked meat	351.1	160.9	190.2	135.6		20.6	3.0	
	Total in meat taken.	660.5	185.4	475.1	144.2		27.1	7.4	

a Determined directly by weighing the meat before and after cooking.
b Determined by subtracting from the total loss in weight the sum of the nutrients found in the broth.

EXPERIMENT No. 22.

This experiment was conducted in exactly the same manner as experiments Nos. 20 and 21. Sample No. 781a was considerably fatter than No. 781b. Both were small and well done.

The weight of the fresh meat used in the first test was 657 grams, and the weight of the same meat cooked (No. 781a) was 384 grams. The loss from cooking was 273 grams, equivalent to 41.6 per cent of the original weight of the meat. The loss of water was 249.5 grams, equivalent to 38 per cent of the original weight of the meat.

The weight of the fresh meat used in the second test was 755.8 grams, and the weight of the same meat cooked (No. 781b) was 424.9 grams. The loss from cooking was 330.9 grams, equivalent to 43.7 per cent of the original weight of the meat. The loss of water was 306.9 grams, equivalent to 40.6 per cent of the original weight of the meat.

The following tables contain the data of the experiment:

TABLE 47.—*Composition of broth and of cooked lean beef (cooking experiment No. 22).*

Lab- ora- tory No.	Sample.	Composition of fresh sub- stance.				Composition of water-free substance.			
		Water.	Pro- tein.	Fat.	Ash.	Nitrogenous matter.		Fat.	Ash.
						Pro- teids.	Flesh bases.		
781a	Broth (suspended matter).....	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>
	Broth (filtered)					6.74		91.60	
	Cooked meat	53.60	34.22	10.31	0.94	12.57	25.51	1.92	23.16
	Broth (suspended matter)					73.76		22.22	2.03
781b	Broth (filtered)					12.03		86.34	
	Broth (suspended matter)					11.07	28.14	1.61	23.70
	Cooked meat	56.11	35.89	6.50	.87	81.78		14.81	1.98

TABLE 48.—Total amounts of constituents in broth from lean beef cooked in water, with amounts in the cooked meat (experiment No. 22).

Lab- ora- tory No.	Sample.	Total weight of ma- terial.	Dry matter directly deter- mined.	Weight of constituents.					
				Water.	Nitrogenous matter.		Fat.	Ash.	Other sub- stances.
					Pro- teids.	Flesh bases.			
781a	FIRST TEST.								
	Broth (suspended matter)	Grams.	Grams.	Grams.	Grams.	Grams.	Grams.	Grams.	Grams.
	Broth (filtered) .....	.....	6.2	.....	0.4	.....	5.7	.....	.....
			17.3		2.2	4.4	.3	4.0	6.4
	Broth (total)	a (273.0)	23.5	b (249.5)	2.6	4.4	6.0	4.0	6.4
	Cooked meat	384.0	178.2	205.8	131.4		39.6	3.6	.....
	Total in meat taken.	657.0	201.7	455.3	138.4		45.6	7.6	.....
781b	SECOND TEST.								
	Broth (suspended matter)		3.9	.....	.5	.....	3.4	.....	.....
	Broth (filtered)		20.1	.....	2.2	5.7	.3	4.8	7.1
	Broth (total)	a (330.9)	24.0	b (306.9)	2.7	5.7	3.7	4.8	7.1
	Cooked meat	424.9	186.5	238.4	152.5		27.6	3.7	.....
	Total in meat taken.	755.8	210.5	545.3	160.8		31.3	8.5	.....

a Determined directly by weighing the meat before and after cooking.
b Determined by subtracting from the total broth the dry matter in the broth.

EXPERIMENT No. 23.

Experiment No. 23 was also conducted in exactly the same manner as experiments Nos. 20 to 22. The samples were small and very well done.

The weight of the fresh meat used in the first test was 742.8 grams, and the weight of the same meat cooked (No. 809a) was 408.1 grams. The loss from cooking was 334.7 grams, equivalent to 45.0 per cent of the original weight of the meat. The loss of water was 307.8 grams, equivalent to 41.4 per cent of the original weight of the meat.

The weight of the fresh meat used in the second test was 686.6 grams, and the weight of the same meat cooked (No. 809b) was 380 grams. The loss from cooking was 306.6 grams, equivalent to 44.7 per cent of the original weight of the meat. The loss of water was 282.9 grams, equivalent to 41.2 per cent of the original weight of the meat.

The following tables contain the data of the experiment:

TABLE 49.—Composition of broth and of cooked lean beef (cooking experiment No. 23).

Lab- ora- tory No.	Sample.	Composition of fresh sub- stance.				Composition of water-free substance.			
		Water.	Pro- tein.	Fat.	Ash.	Nitrogenous matter.		Fat.	Ash.
						Pro- teids.	Flesh bases.		
809a	Broth (suspended matter)	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
	Broth (filtered) .....	.....	.....	.....	.....	3.92	.....	95.56	.....
	Cooked meat	55.09	34.97	9.40	0.85	5.82	29.19	2.13	24.85
	Broth (suspended matter) .....	.....	.....	.....	.....	77.87	.....	20.93	1.89
	Broth (filtered) .....	.....	.....	.....	.....	5.16	.....	94.64	.....
809b	Cooked meat	55.76	37.17	6.34	.94	4.42	29.73	1.42	24.32
						84.02		14.33	2.12

TABLE 50.—*Total amounts of constituents in broth from lean beef cooked in water, with amounts in the cooked meat (experiment No. 23).*

Lab- ora- tory No.	Sample.	Total weight of ma- terial.	Dry matter directly deter- mined.	Weight of constituents.					
				Water.	Nitrogenous matter.		Fat.	Ash.	Other sub- stances.
					Pro- teids.	Flesh bases.			
809a	FIRST TEST.								
	Broth (suspended matter)	Grams.	Grams.	Grams.	Grams.	Grams.	Grams.	Grams.	Grams.
	Broth (filtered)		8.5	.....	0.3	.....	8.1	.....	.....
			18.4	.....	1.1	5.4	.4	4.6	6.9
	Broth (total)	a(334.7)	26.9	b(307.8)	1.4	5.4	8.5	4.6	6.9
	Cooked meat	408.1	183.3	224.8	142.7		38.4	2.5	.....
	Total in meat taken.	742.8	210.2	532.6	149.5		46.9	7.1	.....
809b	SECOND TEST.								
	Broth (suspended matter)		5.4	.....	.3	.....	5.1	.....	.....
	Broth (filtered)		18.3	.....	.8	5.4	.3	4.5	7.3
	Broth (total)	a(306.6)	23.7	b(282.9)	1.1	5.4	5.4	4.5	7.3
	Cooked meat	380.0	168.1	211.9	141.2		24.1	3.6	.....
	Total in meat taken.	686.6	191.8	494.8	147.7		29.5	8.1	.....

a Determined directly by weighing the meat before and after cooking.

b Determined by subtracting from the total broth the dry matter in the broth.

EXPERIMENT No. 24.

In this experiment the meat was prepared in the same way as in experiments Nos. 20 to 23, but was placed in cold water and the temperature gradually raised during thirty minutes to 50° C., at which it was maintained for five hours and thirty minutes. The samples were rather large, not well done, but very rare and juicy after cooking. Meat juice separated out during weighing and grinding, but in so far as was possible this was collected. The broth was thick, contained much suspended matter, and was filtered with difficulty.

The weight of the fresh meat used in the first test was 915.1 grams, and the weight of the same meat cooked (No. 820a) was 784.7 grams. The loss from cooking was 130.4 grams, equivalent to 14.3 per cent of the original weight of the meat. The loss of water was 109.5 grams, equivalent to 12 per cent of the original weight of the meat.

The weight of the fresh meat used in the second test was 837.3 grams, and the weight of the same meat cooked (No. 820b) was 645.8 grams, equivalent to 22.9 per cent of the original weight of the meat. The loss of water was 165.5 grams, equivalent to 19.8 per cent of the original weight of the meat.

The following tables contain the data of the experiment:

TABLE 51.—*Composition of broth and of cooked lean beef (cooking experiment No. 24).*

Lab- ora- tory No.	Sample.	Composition of fresh substance.				Composition of water-free substance.			
		Water.	Pro- tein.	Fat.	Ash.	Nitrogenous matter.		Fat.	Ash.
						Pro- teids.	Flesh bases.		
		<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>
820a	Broth (suspended matter).....	.....	.....	.....	.....	75.03	22.63	.....	.....
	Broth (filtered) .....	.....	.....	.....	.....	14.61	26.56	14.26	22.31
	Cooked meat	68.14	24.87	6.11	0.96	78.06	19.18	3.01	.....
820b	Broth (suspended matter).....	.....	.....	.....	.....	74.79	23.56	.....	.....
	Broth (filtered) .....	.....	.....	.....	.....	17.81	24.99	7.23	20.62
	Cooked meat	66.40	26.42	6.58	.85	78.63	19.59	2.54	.....

TABLE 52.—*Total amounts of constituents in broth from lean beef cooked in water, with amounts in the cooked meat (experiment No. 24).*

Lab- ora- tory No.	Sample.	Total weight of ma- terial.	Dry matter directly deter- mined.	Weight of constituents.					
				Water.	Nitrogenous matter.		Fat.	Ash.	Other sub- stances.
					Pro- teids.	Flesh bases.			
820a	FIRST TEST.	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>
	Broth (suspended matter) .....	.....	5.8	.....	4.4	.....	1.3	.....	.....
	Broth (filtered) .....	.....	15.1	.....	2.2	4.0	2.2	3.4	3.3
	Broth (total)	<i>a</i> (130.4)	20.9	<i>b</i> (109.5)	6.6	4.0	3.5	3.4	3.3
	Cooked meat	784.7	250.0	534.7	195.2	.....	47.9	7.5	.....
	Total in meat taken.	915.1	270.9	644.2	205.8	.....	51.4	10.9	.....
	SECOND TEST.	.....	.....	.....	.....	.....	.....	.....	.....
820b	Broth (suspended matter) .....	.....	7.0	.....	5.2	.....	1.7	.....	.....
	Broth (filtered) .....	.....	19.0	.....	3.4	4.8	1.4	3.9	5.5
	Broth (total)	<i>a</i> (191.5)	26.0	<i>b</i> (165.5)	8.6	4.8	3.1	3.9	5.5
	Cooked meat	645.8	217.0	428.8	170.6	.....	42.5	5.5	.....
	Total in meat taken.	837.3	243.0	594.3	184.0	.....	45.6	9.4	.....

a Determined directly by weighing the meat before and after cooking.

b Determined by subtracting from the total broth the dry matter in the broth.

EXPERIMENT No. 25.

This experiment was similar to experiment No. 17. The meat was prepared for cooking as in experiments Nos. 20 to 24. It was placed in water at 20° C. and the temperature was gradually raised during forty-five minutes to the boiling point. The boiling was continued ten minutes and cold water was then added to reduce the temperature to 80° C., at which it was maintained for two hours. The meat was well done; the broth rather thick. The results of the determination of the fat in the residue from the filtration of sample No. 823a were accidentally lost.

The weight of the fresh meat used in the first test was 798.1 grams and the weight of the same meat cooked (No. 823a) was 461.4 grams.

The loss from cooking was 336.7 grams, equivalent to 42.2 per cent of the original weight of the meat. The loss of water was 314.1 grams, equivalent to 39.4 per cent of the original weight of the meat.

The weight of the fresh meat used in the second test was 944.5 grams and the weight of the same meat cooked (No. 823b) was 558.6 grams. The loss from cooking was 385.9 grams, equivalent to 40.9 per cent of the original weight of the meat. The loss of water was 356.6 grams, equivalent to 37.8 per cent of the original weight of the meat.

The following tables contain the data of the experiment:

TABLE 53.—*Composition of broth and of cooked lean beef (cooking experiment No. 25).*

Lab- ora- tory No.	Sample.	Composition of fresh substance.				Composition of water-free substance.			
		Water.	Pro- tein.	Fat.	Ash.	Nitrogenous matter.		Fat.	Ash.
						Pro- teids.	Flesh bases.		
		<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>
823 a	Broth (suspended matter).....					67.46		28.94	
	Broth (filtered).....					4.54	31.71	7.35	23.49
	Cooked meat.....	58.40	34.82	6.13	0.86	83.70		14.73	2.07
	Broth (suspended matter).....					27.10		68.77	
823 b	Broth (filtered).....					6.16	30.75	6.20	22.97
	Cooked meat.....	59.69	36.30	3.47	.94	90.05		8.61	2.33

TABLE 54.—*Total amounts of constituents in broth from lean beef cooked in water, with amounts in the cooked meat (experiment No. 25).*

Lab- ora- tory No.	Sample.	Total weight of ma- terial.	Dry matter directly deter- mined.	Weight of constituents.					
				Water.	Nitrogenous matter.		Fat.	Ash.	Other sub- stances.
					Pro- teids.	Flesh bases.			
823a	FIRST TEST.								
	Broth (suspended matter).....	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>
	Broth (filtered).....		3.0		2.0		(c)		
			19.6		.9	6.2	1.4	4.6	6.5
	Broth (total).....	a (336.7)	22.6	b (314.1)	2.9	6.2	(c)	4.6	6.5
	Cooked meat.....	461.4	191.9	269.5	160.7		28.3	4.0	
	Total in meat taken.	798.1	214.5	583.6	169.8		30.6	8.6	
	SECOND TEST.								
	Broth (suspended matter).....		6.7		1.8		4.7		
	Broth (filtered).....		22.6		1.4	6.9	1.4	5.2	7.7
823b	Broth (total).....	a (385.9)	29.3	b (356.6)	3.2	6.9	6.1	5.2	7.7
	Cooked meat.....	558.6	225.2	333.4	202.8		19.4	5.3	
	Total in meat taken.	944.5	254.5	690.0	212.9		25.5	10.5	

a Determined directly by weighing the meat before and after cooking.

b Determined by subtracting from the total broth the dry matter in the broth.

c Determination of fat in suspended matter lost.

EXPERIMENT No. 30.

This experiment was made in the same manner and for the same purpose as experiment No. 18, except that in the latter experiment the beef round used was somewhat fatter than that used in the

former. The two pieces of meat of unequal size were cooked for three hours in experiment No. 30 instead of two hours as in experiment No. 18. The small sample, No. 1146, was well done and dry; the large sample, No. 1147, was underdone and juicy.

The weight of the fresh meat used in the first test was 713.6 grams, and the weight of the same meat cooked (No. 1146) was 408.1 grams. The loss from cooking was 305.5 grams, equivalent to 42.8 per cent of the original weight of the meat. The loss of water was 285 grams, equivalent to 39.9 per cent of the original weight of the meat.

The weight of the fresh meat used in the second test was 2,323.1 grams, and the weight of the same meat cooked (No. 1147) was 1,507 grams. The loss from cooking was 816.1 grams, equivalent to 35.2 per cent of the original weight of the meat. The loss of water was 764.7 grams, equivalent to 32.9 per cent of the original weight of the meat.

The following tables contain the data of the experiment:

TABLE 55.—Composition of broth and of cooked lean meat (cooking experiment No. 30).

Lab- ora- tory No.	Sample.	Composition of fresh sub- stance.				Composition of water-free substance.			
		Water.	Pro- tein.	Fat.	Ash.	Nitrogenous matter.		Fat.	Ash.
						Pro- teids.	Flesh bases.		
		<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>
1146	Broth (suspended matter).....	.....	.....	.....	.....	4.11	.....	95.89	.....
	Broth (filtered) .....	.....	.....	.....	.....	5.47	30.72	.89	22.67
	Cooked meat	57.69	33.85	7.74	0.91	80.01	.....	18.30	2.15
	Broth (suspended matter).....	.....	.....	.....	.....	6.85	.....	92.94	.....
1147	Broth (filtered) .....	.....	.....	.....	.....	4.97	30.41	.22	24.27
	Cooked meat	59.49	30.20	10.00	.92	74.56	.....	24.11	2.26

TABLE 56.—Total amounts of constituents in broth from lean beef cooked in water, with amounts in the cooked meat (experiment No. 30).

Lab- ora- tory No.	Sample.	Total weight of ma- terial.	Dry matter directly deter- mined.	Weight of constituents.					
				Water.	Nitrogenous matter.		Fat.	Ash.	Other sub- stances.
					Pro- teids.	Flesh bases.			
1146	FIRST TEST.								
	Broth(suspended matter).....	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>
	Broth (filtered).....	.....	4.5	.....	0.2	.....	4.3	.....	.....
		.....	16.0	.....	.9	4.9	.1	3.6	6.5
	Broth (total)	<i>a</i> (305.5)	20.5	<i>b</i> (285.0)	1.1	4.9	4.4	3.6	6.5
	Cooked meat	408.1	172.7	235.4	138.2	.....	31.6	3.7	.....
	Total in meat taken.	713.6	193.2	520.4	144.2	.....	36.0	7.3	.....
1147	SECOND TEST.								
	Broth(suspended matter).....	.....	9.5	.....	.7	.....	8.8	.....	.....
	Broth (filtered).....	.....	41.9	.....	2.1	12.7	.1	10.2	16.8
	Broth (total)	<i>a</i> (816.1)	51.4	<i>b</i> (764.7)	2.8	12.7	8.9	10.2	16.8
	Cooked meat.....	1,507.0	610.5	896 5	455.1	.....	150.7	13.9	.....
	Total in meat taken.	2,323.1	661.9	1,661.2	470.6	.....	159.6	24.1	.....

a Determined directly by weighing the meat before and after cooking.
b Determined by subtracting from the total broth the dry matter in the broth.

EXPERIMENT No. 31.

This experiment was undertaken for the purpose of showing the influence of the time of cooking upon the resulting losses. Eight pounds of beef round was divided into two nearly equal parts. Each piece was placed in boiling water just sufficient to cover it, and the temperature was kept as near boiling as possible for ten minutes. The first piece (No. 1158) was then cooked at 80° to 85° C. for exactly one and one-half hours, while the second piece (No. 1159) was cooked at the same temperature for five hours. Sample No. 1158 was very rare; sample No. 1159 was dry and tasteless.

The weight of the fresh meat used in the first test was 1,380.2 grams, and the weight of the same meat cooked (No. 1158) was 984.2 grams. The loss from cooking was 396 grams, equivalent to 28.7 per cent of the original weight of the meat. The loss of water was 370.6 grams, equivalent to 26.9 per cent of the original weight of the meat.

The weight of the fresh meat used in the second test was 1,435.9 grams, and the weight of the same meat cooked (No. 1159) was 833.1 grams. The loss from cooking was 602.8 grams, equivalent to 42 per cent of the original weight of the meat. The loss of water was 546.1 grams, equivalent to 38 per cent of the original weight of the meat.

The following tables contain the data of the experiment:

TABLE 57.—*Composition of broth and of cooked lean beef (cooking experiment No. 31).*

Lab- ora- tory No.	Sample.	Composition of fresh substance.				Composition of water-free substance.			
		Water.	Pro- tein.	Fat.	Ash.	Nitrogenous matter.		Fat.	Ash.
						Pro- teids.	Flesh bases.		
		<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>
1158	Broth (suspended matter)					21.11		78.89	
	Broth (filtered)					4.80	29.02	1.05	21.82
	Cooked meat	62.79	29.10	7.10	0.99	78.22		19.07	2.66
	Broth (suspended matter)					8.65		91.35	
1159	Broth (filtered)							.55	22.12
	Cooked meat	55.99	31.93	11.18	.90	72.54		25.41	2.04

TABLE 58.—*Total amounts of constituents in broth from lean beef cooked in water, with amounts in the cooked meat (experiment No. 31).*

Lab- ora- tory No.	Sample.	Total weight of ma- terial.	Dry matter directly deter- mined.	Weight of constituents.					
				Water.	Nitrogenous matter.		Fat.	Ash.	Other sub- stances.
					Pro- teids.	Flesh bases.			
1158	FIRST TEST.								
	Broth (suspended matter).....	Grams.	Grams.	Grams.	Grams.	Grams.	Grams.	Grams.	Grams.
	Broth (filtered).....		3.3		0.7		2.6		
			22.1		1.1	6.4	.2	4.8	9.6
	Broth (total)	a(396.0)	25.4	b(370.6)	1.8	6.4	2.8	4.8	9.6
	Cooked meat	984.2	366.2	618.0	286.4		69.9	9.7	
	Total in meat taken.	1,380.2	391.6	988.6	294.6		72.7	14.5	
	SECOND TEST.								
	Broth (suspended matter).....		15.5		1.3		14.2		
	Broth (filtered).....		41.2				.2	9.1	
1159	Broth (total)	a(602.8)	56.7	b(546.1)			14.4	9.1	
	Cooked meat	833.1	366.7	466.4	266.0		93.1	7.5	
	Total in meat taken.	1,435.9	423.4	1,012.5			107.5	16.6	

a Determined by subtracting from the total broth the dry matter in the broth.
b Determined by weighing the meat before and after cooking.

EXPERIMENT No. 32.

This experiment was made to study the influence of the amount of fat upon the losses involved in boiling meat. For this purpose two boiling pieces cut from the “plate,” each weighing about 4 pounds, were used. The meat was very fat. Each cut was rolled and tied and then placed in boiling water. The temperature was maintained as near boiling as possible for ten minutes. The meat was then cooked at 80° to 85° C. for three hours.

The weight of the fresh meat used in the first test was 1,715.9 grams, and the weight of the same meat cooked (No. 1160) was 1,359.7 grams. The loss from cooking was 356.2 grams, equivalent to 20.8 per cent of the original weight of the meat. The loss of water was 251.3 grams, equivalent to 14.6 per cent of the original weight of the meat.

The weight of the fresh meat used in the second test was 1,825.8 grams, and the weight of the same meat cooked (No. 1161) was 1,354.8 grams. The loss from cooking was 471 grams, equivalent to 25.8 per cent of the original weight of the meat. The loss of water was 297.7 grams, equivalent to 16.3 per cent of the original weight of the meat.

The following tables contain the data of the experiment:

TABLE 59.—*Composition of broth and of cooked fat beef (cooking experiment No. 32).*

Lab- ora- tory. No.	Sample.	Composition of fresh sub- stance.				Composition of water-free substance.			
		Water.	Pro- tein.	Fat.	Ash.	Nitrogenous matter.		Fat.	Ash.
						Pro- teids.	Flesh bases.		
		<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>
1160	Broth (suspended matter).....	.....	.....	.....	.....	1.17	98.83	.....	.....
	Broth (filtered).....	.....	.....	.....	.....	8.16	27.57	1.52	21.38
	Cooked meat.....	34.51	14.88	50.14	0.48	22.72	76.56	.73	.....
	Broth (suspended matter).....	.....	.....	.....	.....	.40	99.60	.....	.....
1161	Broth (filtered).....	.....	.....	.....	.....	6.57	28.14	1.27	21.59
	Cooked meat.....	32.79	16.04	50.73	.41	23.86	75.48	.61	.....

TABLE 60.—*Total amounts of constituents in broth from fat beef cooked in water, with amounts in the cooked meat (experiment No. 32).*

Lab- ora- tory No.	Sample.	Total weight of ma- terial.	Dry matter directly deter- mined.	Weight of constituents.					
				Water.	Nitrogenous matter.		Fat.	Ash.	Other sub- stances.
					Pro- teids.	Flesh bases.			
1160	FIRST TEST.								
	Broth (suspended matter)	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>
	Broth (filtered).....		90.9		1.1		89.8		
			14.0		1.1	3.9	.2	3.0	5.8
	Broth (total)	<i>a</i> (356.2)	104.9	<i>b</i> (251.3)	2.2	3.9	90.0	3.0	5.8
	Cooked meat	1,359.7	890.5	469.2	202.3		681.8	6.5	
	Total in meat taken.	1,715.9	995.4	720.5	208.4		771.8	9.5	
	SECOND TEST.								
	Broth (suspended matter)		154.8		.6		154.2		
	Broth (filtered).....		18.5		1.2	5.2	.2	4.0	7.9
1161	Broth (total)	<i>a</i> (471.0)	173.3	<i>b</i> (297.7)	1.8	5.2	154.4	4.0	7.9
	Cooked meat	1,354.8	910.7	444.1	217.2		687.0	5.6	
	Total in meat taken.	1,825.8	1,084.0	741.8	224.2		841.4	9.6	

a Determined directly by weighing the meat before and after cooking.

b Determined by subtracting from the total broth the total dry matter in the broth.

EXPERIMENT No. 33.

This experiment was made in order to determine the losses resulting by boiling different cuts of beef. The cuts were taken from the neck. The samples were very fat. The meat was cooked exactly as in experiment No. 32.

The weight of the fresh meat used in the first test was 2,393.2 grams, and the weight of the same meat cooked (No. 1162) was 1,977.5 grams. The loss from cooking was 415.8 grams, equivalent to 17.4 per cent of the original weight of the meat. The loss of water was 372.2 grams, equivalent to 15.6 per cent of the original weight of the meat.

The weight of the fresh meat used in the second test was 2,729.8 grams, and the weight of the same meat cooked (No. 1163) was 2,280 grams. The loss from cooking was 449.8 grams, equivalent to 16.5 per cent of the original weight of the meat. The loss of water was 419.5 grams, equivalent to 15.4 per cent of the original weight of the meat.

The following tables contain the data of the experiments:

TABLE 61.—*Composition of broth and of cooked fat beef (cooking experiment No. 33).*

Lab- ora- tory No.	Sample.	Composition of fresh sub- stance.				Composition of water-free substance.			
		Water.	Pro- tein.	Fat.	Ash.	Nitrogenous matter.		Fat.	Ash.
						Pro- teids.	Flesh bases.		
		<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>
1162	Broth (suspended matter) .....	.....	.....	.....	.....	5.63	.....	94.37	.....
	Broth (filtered) .....	.....	.....	.....	.....	10.88	27.45	.39	20.43
	Cooked meat	54.39	21.25	23.62	0.76	46.59	.....	51.79	1.68
	Broth (suspended matter) .....	.....	.....	.....	.....	6.11	.....	93.89	.....
1163	Broth (filtered) .....	.....	.....	.....	.....	13.28	27.95	.74	20.65
	Cooked meat	50.09	19.31	29.87	.70	38.69	.....	59.85	1.40

TABLE 62.—*Total amounts of constituents in broth from fat beef cooked in water, with amounts in the cooked meat (experiment No. 33).*

Lab- ora- tory No.	Sample.	Total weight of ma- terial.	Dry matter directly deter- mined.	Weight of constituents.					
				Water.	Nitrogenous matter.		Fat.	Ash.	Other sub- stances.
					Pro- teids.	Flesh bases.			
1162	FIRST TEST.								
	Broth (suspended matter)	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>
	Broth (filtered) .....	.....	20.9	.....	1.2	.....	19.7	.....	.....
	.....	.....	22.7	.....	2.5	6.2	.1	4.6	9.3
	Broth (total)	a(415.8)	43.6	b(372.2)	3.7	6.2	19.8	4.6	9.3
	Cooked meat	1,977.5	901.9	1,075.6	420.2	.....	467.1	15.0	.....
	Total in meat taken.	2,393.3	945.5	1,447.8	430.1	.....	486.9	19.6	.....
	SECOND TEST.								
	Broth (suspended matter) .....	.....	9.0	.....	.6	.....	8.5	.....	.....
	Broth (filtered) .....	.....	21.3	.....	2.8	5.9	.2	4.4	8.0
1163	Broth (total)	a(449.8)	30.3	b(419.5)	3.4	5.9	8.7	4.4	8.0
	Cooked meat	2,280.0	1,138.0	1,142.0	440.3	.....	681.0	16.0	.....
	Total in meat taken.	2,729.8	1,168.3	1,561.5	449.6	.....	689.7	20.4	.....

a Determined directly by weighing the meat before and after cooking.

b Determined by subtracting from the total broth the total dry matter in the broth.

EXPERIMENT No. 38.

This experiment was made to determine the losses resulting from boiling veal. Two pieces of veal were cooked in the same way as in experiment No. 32.

The weight of the fresh meat used in the first test was 1,774.2 grams, and the weight of the same meat cooked (No. 1177) was 1,189.2 grams. The loss from cooking was 585 grams, equivalent to 33 per cent of the original weight of the meat. The loss of water was 538.7 grams, equivalent to 30.4 per cent of the original weight of the meat.

The weight of the fresh meat used in the second test was 2,334.7 grams, and the weight of the same meat cooked (No. 1178) was 1,597.6 grams. The loss from cooking was 737.1 grams, equivalent to 31.6 per cent of the original weight of the meat. The loss of water was 697.5 grams, equivalent to 29.9 per cent of the original weight of the meat.

The following tables contain the data of the experiment:

TABLE 63.—*Composition of broth and of cooked veal (cooking experiment No. 38).*

Lab- ora- tory No.	Sample.	Composition of fresh sub- stance.				Composition of water-free substance.			
		Water.	Pro- tein.	Fat.	Ash.	Nitrogenous matter.		Fat.	Ash.
						Prote- ids.	Flesh bases.		
		<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>
1177	Broth (suspended matter)					7.41		92.59	
	Broth (filtered)					19.72	25.37	.27	19.27
	Cooked meat	64.07	27.22	7.79	0.98	75.75		21.64	2.73
	Broth (suspended matter)					32.17		67.83	
1178	Broth (filtered)					21.45	25.75	.44	19.83
	Cooked meat	67.59	27.59	4.18	.99	85.12		12.89	3.05

TABLE 64.—*Total amounts of constituents in broth from veal cooked in water, with amounts in the cooked meat (experiment No. 38).*

Lab- ora- tory No.	Sample.	Total weight of ma- terial.	Dry matter directly deter- mined.	Weight of constituents.					
				Water.	Nitrogenous matter.		Fat.	Ash.	Other sub- stances.
					Prote- ids.	Flesh bases.			
1177	FIRST TEST.								
		<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>
	Broth (suspended matter)		14.9		1.1		13.8		
	Broth (filtered)		31.4		6.2	8.0	.1	6.1	11.0
	Broth (total)	<i>a</i> (585.0)	46.3	<i>b</i> (538.7)	7.3	8.0	13.9	6.1	11.0
	Cooked meat	1,189.2	427.3	761.9	323.7		92.6	11.7	
	Total in meat taken.	1,774.2	473.6	1,300.6	339.0		106.5	17.8	
1178	SECOND TEST.								
	Broth (suspended matter)		4.3		1.4		2.9		
	Broth (filtered)		35.3		7.6	9.1	.2	7.0	11.4
	Broth (total)	<i>a</i> (737.1)	39.6	<i>b</i> (697.5)	9.0	9.1	3.1	7.0	11.4
	Cooked meat	1,597.6	517.8	1,079.8	440.8		66.8	15.8	
	Total in meat taken.	2,334.7	557.4	1,777.3	458.9		69.9	22.8	

a Determined directly by weighing the meat before and after cooking.

b Determined by subtracting from total broth the dry matter in the broth.

EXPERIMENT No. 39.

This experiment was undertaken to determine the losses resulting from boiling mutton. For this purpose cuts from a leg of mutton were used. They were cooked as in experiment No. 32.

The weight of the fresh meat used in the first test was 964.7 grams, and the weight of the same meat cooked (No. 1179) was 587 grams. The loss from cooking was 377.7 grams, equivalent to 39.2 per cent of the original weight of the meat. The loss of water was 278.6 grams, equivalent to 28.9 per cent of the original weight of the meat.

The weight of the fresh meat used in the second test was 1,284.2 grams, and the weight of the same meat cooked (No. 1180) was 835.8 grams. The loss from cooking was 448.4 grams, equivalent to 34.9 per cent of the original weight of meat. The loss of water was 354.6 grams, equivalent to 27.6 per cent of the original weight of the meat.

The following tables contain the data of the experiment:

TABLE 65.—Composition of broth and of cooked mutton (cooking experiment No. 39).

Lab- ora- tory No.	Sample.	Composition of fresh sub- stance.				Composition of water-free substance.			
		Water.	Pro- tein.	Fat.	Ash.	Nitrogenous matter.		Fat.	Ash.
						Prote- ids.	Flesh bases.		
		<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>
1179	Broth (suspended matter).....					0.82		99.18	
	Broth (filtered).....					7.59	31.41	0	21.45
	Cooked meat	47.88	26.14	25.50	0.75	50.15		48.88	1.44
	Broth (suspended matter).....					.37		98.27	
1180	Broth (filtered).....					10.24	28.97	0	19.76
	Cooked meat	51.42	29.24	18.57	.86	60.19		38.22	1.77

TABLE 66.—Total amounts of constituents in broth from mutton cooked in water, with amounts in the cooked meat (experiment No. 39).

Lab- ora- tory No.	Sample.	Total weight of ma- terial.	Dry matter directly deter- mined.	Weight of constituents.					
				Water.	Nitrogenous matter.		Fat.	Ash.	Other sub- stances.
					Pro- teids.	Flesh bases.			
1179	FIRST TEST.								
	Broth (suspended matter).....	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>
	Broth (filtered).....		80.2		0.7	5.9	79.6		7.6
			18.9		1.4		0	4.0	
	Broth (total)	<i>a</i> (377.7)	99.1	<i>b</i> (278.6)	2.1	5.9	79.6	4.0	7.6
	Cooked meat	587.0	305.9	281.1	153.4		149.7	4.4	
	Total in meat taken.	964.7	405.0	559.7	161.4		229.3	8.4	
	SECOND TEST.								
	Broth (suspended matter).....		69.5		.3		68.3		
	Broth (filtered).....		24.3		2.5	7.0	0	4.8	10.0
1180	Broth (total)	<i>a</i> (448.4)	93.8	<i>b</i> (354.6)	2.8	7.0	68.3	4.8	10.0
	Cooked meat	835.8	406.0	429.8	244.4		155.2	7.2	
	Total in meat taken.	1,284.2	499.8	784.4	254.2		223.5	12.0	

a Determined directly by weighing the meat before and after cooking.

b Determined by subtracting from the total broth the dry matter in the broth.

The losses involved in the cooking of meats in water at different temperatures have been represented in the preceding tables by the ingredients in the total broth. In the following table the losses of the different ingredients are expressed in percentages of the total quantity of meat taken for cooking, and also in percentages of the total amounts of the corresponding ingredients in the uncooked meat. This table summarizes the data concerning the kind and amount of meat used in each experiment, the temperatures at the beginning and during the time of cooking, and the duration of the cooking. Most of the experiments are arranged in groups according to the kind of meat and the method of cooking, and the results of all the experiments in each group are averaged. Several of the experiments differed so greatly from the majority that they could not well be grouped with them, and hence stand alone. With two exceptions (Nos. 8 and 9) each experiment included duplicate tests, designated in this table by the letters a and b, the results of these duplicate tests being averaged in each case.

TABLE 67.—*Losses involved in the cooking of meats in water at different temperatures.*

Experiment No.	Meat used for cooking.		Water used in cooking.			Dura- tion.	Total loss and loss of different constituents in percentages of total weight of uncooked meat.						Loss of different constituents in percentages of total amounts in uncooked meat.			
	Kind.	Amount.	Amount.	Tem- per- ature at begin- ning.	Tem- per- ature during cook- ing.		Total weight.	Water.	Total nitro- genous mate- rial.	Fat.	Ash.	Other sub- stances.	Water.	Total nitro- genous mate- rial.	Fat.	Ash.
4a 4b	Lean beef; visible fat removed.....	Grams. ¹ 1,082.2	Ct. 1,500	° C. 100	° C. 80-85	Hours. 2 $\frac{1}{3}$	Per ct. 38.3	Per ct. 36.1	Per ct. 1.5	Per ct. 0.2	Per ct. 0.5	Per ct.	Per ct. 49.2	Per ct. 6.5	Per ct. 10.0	Per ct. 41.6
	do.....	1,064.9	1,500	100	80-85	2 $\frac{1}{3}$	41.0	38.6	1.4	.5	.5	.....	52.7	6.1	23.5	47.9
	Average.....	.....	.....	.....	.....	.....	39.7	37.3	1.5	.4	.5	.....	50.9	6.3	16.7	44.8
5a 5b	Lean beef; visible fat removed.....	1,176.0	1,500	100	80-85	2 $\frac{1}{3}$	35.3	33.8	1.0	.2	.3	.....	47.6	3.9	7.5	27.8
	do.....	856.0	1,500	100	80-85	2 $\frac{1}{3}$	34.0	31.9	1.2	.5	.4	.....	45.2	5.3	9.5	36.5
	Average.....	.....	.....	.....	.....	.....	34.7	32.9	1.1	.3	.4	.....	46.4	4.6	8.5	32.2
7a 7b	Lean beef; visible fat removed.....	758.0	2,000	100	85	2 $\frac{1}{3}$	35.3	33.5	.9	.3	.6	.....	48.1	3.7	4.6	48.9
	do.....	888.9	2,000	100	85	2 $\frac{1}{3}$	41.8	40.1	.9	.2	.6	.....	55.3	4.5	4.4	50.0
	Average.....	.....	.....	.....	.....	.....	38.6	36.8	.9	.3	.6	.....	51.7	4.1	4.5	49.5
8 20a 20b	Lean beef; visible fat removed.....	863.4	2,000	100	87	2 $\frac{1}{3}$	45.2	43.4	1.0	.2	.6	.....	58.7	4.3	6.5	56.3
	do.....	825.8	2,000	100	80	2	42.2	38.9	1.0	1.2	.6	.....	54.8	5.2	16.1	54.4
	do.....	739.5	2,000	100	80	2	42.9	39.2	1.2	1.3	.6	.....	56.3	5.6	16.8	54.8
21a 21b	Average.....	.....	.....	.....	.....	.....	42.6	39.1	1.1	1.3	.6	.....	55.6	5.4	16.5	54.6
	Lean beef; visible fat removed.....	750.0	2,000	100	80	2	46.3	42.5	1.2	1.5	.6	.....	59.9	5.6	23.3	59.3
	do.....	660.5	2,000	100	80	2	46.8	43.1	1.3	1.0	.7	.....	60.0	6.0	24.0	59.5
22a 22b	Average.....	.....	.....	.....	.....	.....	46.6	42.8	1.3	1.3	.7	.....	60.0	5.8	23.6	59.4
	Lean beef; visible fat removed.....	657.0	2,000	100	80	2	41.6	38.0	1.1	.9	.6	.....	54.8	5.1	13.1	52.6
	do.....	755.8	2,000	100	80	2	43.7	40.6	1.1	.5	.6	.....	56.3	5.2	11.8	56.5
23a 23b	Average.....	.....	.....	.....	.....	.....	42.7	39.3	1.1	.7	.6	.....	55.6	5.2	12.5	54.6
	Lean beef; visible fat removed.....	742.8	2,000	100	80	2	45.0	41.4	.9	1.2	.6	.....	57.8	4.5	18.1	64.8
	do.....	686.6	2,000	100	80	2	44.7	41.2	.9	.8	.7	.....	57.2	4.4	18.3	55.6
Average, 8 experiments (15 tests)	Average.....	.....	.....	.....	.....	.....	44.9	41.3	.9	1.0	.7	.....	57.5	4.5	18.2	60.2
	Average, 8 experiments (15 tests).....	.....	.....	.....	.....	.....	41.6	38.8	1.1	.7	.6	.....	54.3	5.1	13.4	51.1

¹ 28 grams=1 ounce; 454 grams=1 pound.² Placed in 1,500 cubic centimeters water and about 500 cubic centimeters cold water added during cooking.

TABLE 67.—*Losses involved in the cooking of meats in water at different temperatures—Continued.*

Experiment No.	Meat used for cooking.		Water used in cooking.				Total loss and loss of different constituents in percentages of total weight of uncooked meat.						Loss of different constituents in percentages of total amounts in uncooked meat.			
	Kind.	Amount.	Amount.	Temperature at beginning.	Temperature during cooking.	Duration.	Total weight.	Water.	Total nitrogeous material.	Fat.	Ash.	Other substances.	Water.	Total nitrogeous material.	Fat.	Ash.
6a	Lean beef; visible fat removed.	Grams. ¹ 1,623.5	Cc. 2,000	20-25	° C. 83-89	Hours. 4 $\frac{1}{2}$	Per ct. 44.2	Per ct. 42.3	Per ct. 0.8	Per ct. 0.5	Per ct. 0.6	Per ct.	Per ct. 56.4	Per ct. 3.7	Per ct. 25.9	Per ct. 44.1
6b	do	1,119.8	2,000	20-25	83-89	4 $\frac{1}{2}$	44.7	43.0	.8	.3	.6	.....	57.0	3.8	15.4	51.2
	Average	.....	.....	.....	.....	.....	44.5	42.7	.8	.4	.6	.....	56.7	3.8	20.7	47.7
17a	Lean beef; visible fat removed.	705.5	2,000	20-25	80	2	41.0	37.5	1.1	.8	.6	.....	50.2	6.1	16.3	56.3
17b	do	660.8	2,000	20-25	80	2	41.2	37.3	1.1	1.2	.6	.....	56.6	6.0	22.0	57.4
	Average	.....	.....	.....	.....	.....	41.1	37.4	1.1	1.0	.6	.....	53.4	6.1	19.1	56.9
25a	Lean beef; visible fat removed.	798.1	2,000	20-25	80	2	42.2	39.4	1.1	.....	.6	.....	53.8	5.4	.....	53.5
25b	do	944.5	2,000	20-25	80	2	40.9	37.8	1.1	.6	.6	.....	51.7	4.7	23.9	49.5
	Average	.....	.....	.....	.....	.....	41.6	38.6	1.1	.....	.6	.....	52.8	5.1	.....	51.5
	Average, 3 experiments (6 tests)	.....	.....	.....	.....	.....	42.4	39.6	1.0	.6	.6	.....	54.3	5.0	20.7	52.0
24a	Lean beef; visible fat removed.	915.1	2,000	20-25	50	5 $\frac{1}{2}$	14.3	12.0	1.2	.4	.4	.3	17.0	5.2	6.8	31.2
24b	do	837.3	2,000	20-25	50	5 $\frac{1}{2}$	22.9	19.8	1.6	.4	.5	.6	27.9	7.8	6.8	41.5
	Average	.....	.....	.....	.....	.....	18.6	15.9	1.4	.4	.5	.4	22.6	6.5	6.8	36.4
9a	Lean beef; visible fat removed; ground.	442.0	1,500	100	80	2	36.0	34.6	.8	.1	.5	.....	47.9	3.9	2.1	46.0
10a	Lean beef; visible fat not removed.	1,300.2	1,500	100	80	3	45.2	38.9	1.1	4.6	.6	.....	58.1	5.4	37.4	58.3
10b	do	1,283.1	2,000	100	80	3	43.8	37.2	1.2	4.9	.5	.....	56.3	6.3	35.8	57.0
	Average	.....	.....	.....	.....	.....	44.5	38.0	1.2	4.7	.6	.....	57.2	5.9	36.6	57.7
13a	Lean beef; visible fat not removed.	2,580.0	2,000	100	80	2	28.5	27.4	.5	.2	.3	.....	35.9	2.7	5.3	33.0
13b	do	2,180.0	2,000	100	80	2	35.8	34.6	.6	.2	.4	.....	47.3	3.0	3.5	36.8
	Average	.....	.....	.....	.....	.....	32.2	31.0	.6	.2	.4	.....	41.6	2.9	4.4	34.9
18a	Lean beef; visible fat not removed.	433.2	(4)	100	80-85	2	48.5	45.3	1.1	.4	.7	1.0	59.5	5.3	24.1	64.0
18b	do	2,080.6	(4)	100	80-88	2	44.5	41.6	1.0	.4	.6	.8	55.6	4.8	17.3	51.7
	Average	.....	.....	.....	.....	.....	46.5	43.4	1.1	.4	.7	.9	57.6	5.1	20.7	57.9

30a	Lean beef; visible fat not removed	713.6	(4)	100	80-85	3	42.8	39.9	.9	.6	.5	.9	54.8	4.2	12.2	49.3
30b	do	2,325.1	(4)	100	80-85	3	35.1	32.9	.7	.4	.4	.7	46.0	3.3	5.6	42.3
	Average						39.0	36.4	.8	.5	.5	.8	50.4	3.8	8.9	45.8
	Average, 4 experiments (8 tests)						40.5	37.2	.9	1.5	.5	.4	51.7	4.4	17.7	49.1
31a	Lean beef; visible fat not removed	1,380.2	(4)	100	80-85	1½	28.7	26.9	.6	.2	.3	.7	37.5	2.8	3.9	33.1
31b	do	1,435.9	(4)	100	80-85	5	42.0	38.0		1.0	.6		53.9		13.4	54.8
	Average						35.4	32.5		.6	.5		45.7		8.7	44.0
11a	Lean beef; visible fat not removed	1,222.5	1,000	20-25	85	4½	44.0		.9		.5			4.5		55.4
11b	do	1,461.0	1,500	20-25	85	4½	34.1	32.4	.8	.4	.5		50.4	4.1	2.7	48.2
	Average						39.1		.9		.5			4.3		51.8
14a	Lean beef; visible fat not removed	2,020.0	2,000	20-25	65-70	4	27.0	26.2	.3	.1	.4		35.3	1.8	1.2	32.5
14b	do	2,870.0	2,000	20-25	65-70	4	25.3	24.6	.3	.1	.3		33.8	1.6	.6	29.0
	Average						26.2	25.4	.3	.1	.4		34.6	1.7	.9	30.8
16a	Fat beef	1,220.3	(4)	100	80-85	2	34.4	31.8	.7	.9	.5	.5	48.4	3.9	6.7	45.5
16b	do	1,477.8	(4)	100	80-85	2	33.9	31.3	.7	1.0	.4		47.4	4.0	7.4	41.5
	Average						34.2	31.6	.7	1.0	.4	.5	47.9	4.0	7.1	43.5
32a	Fat beef	1,715.9	(5)	100	80-85	3	20.8	14.6	.4	5.3	.2	.3	34.9	2.9	11.7	31.6
32b	do	1,825.8	(5)	100	80-85	3	25.8	16.3	.4	8.5	.2	.4	40.1	3.1	18.3	41.7
	Average						23.3	15.4	.4	6.9	.2	.4	37.5	3.0	15.0	36.6
33a	Fat beef	2,393.2	(5)	100	80-85	3	17.4	15.6	.4	.8	.2	.4	25.7	2.3	4.1	23.5
33b	do	2,729.8	(5)	100	80-85	3	16.5	15.4	.3	.3	.2	.3	26.9	2.1	1.3	21.6
	Average						17.0	15.5	.4	.6	.2	.3	26.3	2.2	2.7	22.6
	Average, 3 experiments (6 tests)						24.8	20.8	.5	2.8	.3	.4	37.2	3.1	8.3	34.2
38a	Veal	1,774.2	(5)	100	80-85	3	33.0	30.4	.9	.8	.3	.6	41.4	4.5	13.1	34.3
38b	do	2,334.7	(5)	100	80-85	3	31.6	29.9	.8	.1	.3	.5	39.2	3.9	4.4	30.7
	Average						32.3	30.1	.8	.5	.3	.6	40.3	4.2	8.7	32.5
39a	Mutton	964.7	(5)	100	80-85	3	39.2	28.9	.8	8.3	.4	.8	49.8	4.9	34.7	47.6
39b	do	1,284.2	(5)	100	80-85	3	34.9	27.6	.8	5.3	.4	.8	45.2	3.9	30.6	40.0
	Average						37.1	28.3	.8	6.8	.4	.8	47.5	4.4	32.7	43.8
	Average, all experiments (48 tests)						36.7	33.6	.9	1.3	.5	.4	48.0	4.4	13.5	45.9

¹ 28 grams = 1 ounce; 454 grams = 1 pound.² Placed in 1,500 cubic centimeters water and about 500 cubic centimeters cold water added during cooking.³ Placed in 1,000 cubic centimeters boiling water; 500 cubic centimeter scold water added.⁴ Just sufficient to cover meat.⁵ Amount not recorded.

DISCUSSION OF RESULTS.

AMOUNT AND NATURE OF LOSSES INVOLVED IN THE BOILING AND STEWING OF MEAT.

In the preceding experiments on the losses resulting from the boiling and stewing of meats, the loss in weight varied from about one-seventh to about one-half of the total weight of fresh meat, the average of all the experiments being nearly 37 per cent. About nine-tenths of this loss was due to water cooked out of the meat, while the remainder was due to the removal of solid material, which was contained in the broth either as suspended matter or in solution. In the different experiments the loss of water varied from 17 to 60 per cent, averaging 48.0 per cent of the total amount in the fresh meat. The proportions of the remaining ingredients of the fresh meat that were found in the total broth were as follows: Nitrogenous matter from 1.6 to 6.5 per cent, average 4.4 per cent; fat from 0.6 to 37.4 per cent, average 13.5 per cent; mineral matter from 21.6 to 64.8 per cent, average 45.9 per cent.

By a comparison of the average results of eight experiments (fifteen tests) in which very lean beef was used and those of three experiments (six tests) in which fat beef was used, it appears that in the latter case there was less loss of water and of nitrogenous and mineral matters, but a greater loss of fat than in the former. The comparative losses in percentages of fresh meat used were as follows:

TABLE 68.—Average losses in cooking lean and fat beef.

Sample.	Total loss.	Water.	Nitrogenous matter.	Fat.	Ash.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Lean beef	41.6	38.8	1.1	0.7	0.6
Fat beef	24.8	20.8	.5	2.8	.3

In an experiment in which veal, which is a lean meat, was used, there was a corresponding loss of 0.5 per cent of fat, while in a similar experiment with mutton, which is a much fatter meat, the loss was 6.8 per cent. The proportion of fat lost thus appears to depend upon the fatness of the meat. At the same time the fatter the meat the smaller the loss of water.

In experiments Nos. 18 and 30 the first test was made with a piece of lean beef weighing 1 to $1\frac{3}{4}$ pounds, while the second test was made with a piece weighing 5 to $5\frac{1}{2}$ pounds, in order to study the effect of the size of the piece of meat used upon the loss involved in the cooking. With the small pieces the average loss in weight was 45.6 per cent of the total weight of meat, while with the large pieces it was

only 39.8 per cent. With the small pieces an average of 57.2 per cent of the total water, 4.7 per cent of the total nitrogenous matter, 18.2 per cent of the total fat, and 56.7 per cent of the total mineral matter in the fresh meat was found in the broth, while with the large pieces the corresponding results were water 50.8 per cent, nitrogenous matter 4 per cent, fat 11.5 per cent, and ash 47 per cent. These results indicate that the smaller the piece of meat the larger the percentage of losses. Apparently the water penetrates relatively farther into the small piece and removes more material.

Some interesting facts are brought out in a comparison of the results of experiments in which the meat was cooked by starting with boiling water with the results of other experiments in which the water was cold at the start. In eight experiments (fifteen tests) very lean beef was put into boiling water, and this temperature maintained for about ten minutes, after which the cooking was continued at a temperature of 80° to 85° C. for two to two and one-third hours. In three experiments (six tests) the same kind of meat was put into cold water (20° to 25° C.), the temperature was increased to near the boiling point, and the cooking was then carried on at 80° to 89° C. for two to four and one-half hours. The amount of suspended, coagulated nitrogenous matter in the broth which could be filtered out was usually larger in the experiments in which the meat was put directly into cold water, and the broth was thicker and apparently richer than when the meat was placed directly in boiling water. On the other hand, there was usually a greater amount of solids in solution in the clear filtered broth when the meat was put at first into boiling water, so that the analyses of the total broths show that as a rule the composition of the broths obtained by the two methods of cooking was much the same. In the eight experiments in which the meat was put directly into boiling water the average loss of weight was 41.6 per cent of the total weight of the meat, while in the three experiments in which the meat was put into cold water it was 42.4 per cent. In the average of the former experiments 54.3 per cent of the total water, 5.1 per cent of the total nitrogenous matter, 13.4 per cent of the total fat, and 51.1 per cent of the total mineral matter of the fresh meat were found in the broth, while in the average of the latter experiments the losses were water 54.3, nitrogenous matter 5, fat 20.7, and mineral matter 52 per cent of the respective nutrients in the fresh meat. The agreement is very close except in the case of the fat.

It is usually supposed that if meat is placed in cold water and the temperature is then raised gradually a large part of its soluble ingredients is dissolved and a rich broth is obtained. In the experiments here reported it was found that the loss from the meat, represented by the ingredients in the broth, was really no greater when the meat was placed in cold water than when placed in boiling water.

In experiment No. 31 two tests were made which were alike except that in the first the meat was cooked for one and one-half hours while in the second test the cooking was carried on for five hours. In the first test the loss of weight was 28.7 per cent and in the second test 42 per cent of the original weight of the meat. In the first test 37.5 per cent of the total water, 2.8 per cent of the total nitrogenous matter, 3.9 per cent of the total fat, and 33.1 per cent of the total mineral matter in the meat was removed; while in the second test 53.9 per cent of the total water, 13.4 per cent of the total fat, and 54.8 per cent of the total mineral matter of the meat were removed by cooking. Unfortunately, in the latter test the data for protein were lost, but the comparison of the results given is sufficient to indicate that the loss increased with the increase in the time of cooking.

As previously explained (p. 13), the bromin method was used for the precipitation of proteids in the clear filtered broth. The amount of nitrogen in the bromin precipitate was determined and multiplied by the factor 6.25 for estimating the quantity of proteids. The amount of nitrogen in the total broth was also determined, and the difference between that and the amount in the bromin precipitate was multiplied by the factor 3.12 for the estimation of the quantity of flesh bases in the broth. The fat was determined by extraction with ether and the mineral salts by ignition. The proportions of solid materials extracted from the meat in the cooking and contained in the filtered broth were determined directly by evaporation. The sum of the nitrogenous matters, fat, and mineral matter, determined as indicated above, was in each case considerably less than the total solid residue on evaporation. Evidently, therefore, the broth contained a considerable amount of substances other than the nitrogenous compounds, fat, and mineral matters determined. The amounts of total solids directly determined, the sum of the ingredients separately determined, and the difference between the two, designated as "other substances," are shown in Table 69. The last column in this table shows the proportions of the "other substances" in percentages of the total solids.

TABLE 69.—*Amount and proportion of undetermined matter in broth.*

Experiment No.	Total solids directly determined (a).	Sum of con- stituents determined (b).	Other substances unde- termined.	
			Weight (a-b).	Proportion of total solids. $\left(\frac{a-b}{a}\right)$
	Grams.	Grams.	Grams.	Per cent.
16a	21.2	15.2	6.0	28.3
16b	25.3	18.1	7.2	28.5
17a	17.3	10.7	6.6	38.2
17b	16.6	10.4	6.2	37.4
18a	12.7	8.6	4.1	32.3
18b	51.1	34.1	17.0	33.3
20a	20.4	16.0	4.4	21.6
20b	19.9	15.9	4.0	20.1
21a	20.1	16.1	4.0	19.9
21b	19.3	14.3	5.0	25.9
22a	17.3	10.9	6.4	37.0
22b	20.1	13.0	7.1	35.3
23a	18.4	11.5	6.9	37.5
23b	18.3	11.0	7.3	39.9
24a	15.1	11.8	3.3	21.9
24b	19.0	13.5	5.5	29.0
25a	19.6	13.1	6.5	33.2
25b	22.6	14.9	7.7	34.1
30a	16.0	9.5	6.5	40.6
30b	41.9	25.1	16.8	40.1
31a	22.1	12.5	9.6	43.4
32a	14.0	8.2	5.8	41.4
32b	18.5	10.6	7.9	42.7
33a	22.7	13.4	9.3	41.0
33b	21.3	13.3	8.0	37.6
38a	31.4	20.4	11.0	35.0
38b	35.3	23.9	11.4	32.3
39a	18.9	11.3	7.6	40.2
39b	24.3	14.3	10.0	41.2
Average 29 tests.....	22.1	14.5	7.6	34.2

The proportions of the undetermined material, or “other substances,” as they are here called, thus range from 19.9 to 43.4 per cent and average 34.2 per cent of the total solids of the clear broth; or, as shown in Table 67, the proportions of these substances range from 0.3 to 1.1 per cent, and average 0.4 per cent of the total weight of the fresh meat.

Considerable attention has already been given by the writer to the study of the composition of the broths and the nature of these undetermined substances, but the publication of the results is withheld until the inquiry can be carried further. It is evident that these substances contain more or less glycogen or its derivatives and other non-nitrogenous compounds. At the same time it is possible that the undetermined materials may include more or less nitrogenous material which has not been accurately determined by the methods thus far employed.

CONCLUSIONS.

While the investigations of the losses in cooking meat are still very inadequate, the conclusions given below seem warranted from the results of the experiments reported in this bulletin. Most of these

experiments were made with lean beef, but it is probable that the results with other lean meats would be similar.

(1) The chief loss in weight during the cooking of beef is due to the driving off of water.

(2) When beef is "pan-broiled" there appears to be no great loss of nutritive material.

(3) When beef is cooked in water from 3 to 20 per cent of the total solids is found in the broth. The material thus removed from the meat has been designated as a loss, but is not an actual loss if the broth is utilized for soup or in other ways.

(4) Beef which has been used for the preparation of beef tea or broth has lost comparatively little nutritive value, though much of the flavoring material has been removed.

(5) The amount of fat found in the broth varies directly with the amount present in the meat—i. e., the fatter the meat the larger the quantity in the broth.

(6) The amount of water lost during cooking varies inversely as the fatness of the meat—i. e., the fatter the meat the less the shrinkage in cooking.

(7) In cooking in water the loss of constituents is inversely proportional to the size of the piece of meat. In other words, the smaller the piece the greater the percentage of loss.

(8) The loss appears to depend upon the length of time of cooking.

(9) When meat in pieces weighing from $1\frac{1}{2}$ to 5 pounds is cooked in water at 80° to 85° C. (175° to 185° F.) there appears to be little difference in the amount of material found in the broth whether the meat is placed in cold water or hot water at the start.

(10) The nature of the nitrogenous ingredients of the broth is not yet fully understood. This subject is now being studied in connection with further inquiries regarding the changes in meat in cooking.

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